THE UNIVERSITY OF TEXAS AT AUSTIN Date: 9/4/13

RECOMMENDATION FOR CHANGE IN ACADEMIC RANK/STATUS

Name: Mikhail Belkin Present Rank: Assistant Professor

Years of Academic Service *(Include AY 2013-14 in each count)*:

At UT Austin since: 9/1/08 (m/d/y) In present rank: 6 (# of years); In Probationary Status (TT **only**): 6 (# of years)

Department: Electrical and Computer Engineering

Other: _____

College/School: Cockrell School of Engineering

Recommended action[1]:

By Budget Council/Executive Committee: Promote to Associate Professor

Vote[2] for promotion 27; Against 0; Abstain 0; Absent 8

By Department Chair: Promote to Associate Professor

By SBS Executive Committee: _____

Vote[2] for promotion _____; Against _____; Abstain _____; Absent _____

By Director: _____

By College/School Advisory Committee: Promote

Vote[2] for promotion 7; Against 0; Abstain 0; Absent 0

By Dean: Promote

Administrative Action: Promote to Associate Professor

Date Action Effective: September 1, 2014
(To be submitted to the Board of Regents as part of the annual budget.)

By: _____ Date: 12/16/2013
For the President

[1]See "Chart of Recommended Actions" for eligible recommended actions applicable to specific conditions and administrative levels.

[2]All votes are to be recorded as For, Against, or Abstain. (Note: unexplained abstentions will be interpreted as weak negative votes by the President's Committee.) Also record number of absent eligible voting members.

EVPP/4.13

EXHIBIT
P's 145

Dean's Assessment
Mikhail Belkin
Department of Electrical and Computer Engineering

Mikhail Belkin received a BS degree in Applied Physics and Mathematics from the Moscow Institute of Physics and Technology in 1998, and MA (2000) and PhD (2004) degrees in Physics from the University of California at Berkeley. Between 2004 and 2008, Dr. Belkin was a postdoctoral fellow and a research associate in the School of Engineering and Applied Sciences at Harvard University. He was appointed an assistant professor at UT Austin in 2008.

Ten external review letters were submitted as part of the promotion dossier, five were suggested by the candidate and five were selected by the budget council. Seven reviewers are faculty at US universities, two are faculty at European universities, and one is a senior scientist at a DOD research laboratory. One reviewer is a member of NAE and another is a member of NAS.

Teaching
Dr. Belkin has taught one undergraduate course and two graduate courses: EE 325, *Electromagnetic Engineering* (three times); EE 396V, *Nanostructured Optoelectronics* (one time); and EE 383V, *Nonlinear Optics* (four times). His average overall instructor/course ratings for these courses are 3.67/3.30, 4.3/4.0, and 4.45/4.27, respectively. Dr. Belkin also supervised a three-student, senior design project team during the 2012 spring and summer semesters.

The weighted average/median instructor ratings in the Department of Electrical and Computer Engineering over the last five years are 4.06/4.08 for assistant professors teaching undergraduate courses and 4.22/4.36 for assistant professors teaching graduate courses.

Dr. Belkin's instructor ratings in EE 325 are below the department average for undergraduate courses; however, this course appears to be difficult to teach. Over the past six years, 31 sections of EE 325 have been offered by eight tenured and tenure-track faculty and only two faculty members have achieved an average instructor rating in EE 325 that exceeds the median for undergraduate courses in the department. The peer review report for EE 325 indicated that Dr. Belkin engaged the students and was very clear in his presentation of the material.

Research
Dr. Belkin's research focuses on novel optoelectronic and optomechanical devices, metamaterials, and photonic systems operating in mid-infrared (mid-IR) and terahertz (THz) spectra. His primary research contributions in rank are (1) room-temperature, compact THz lasers and (2) development of quantum cascade laser systems for mid-infrared molecular spectroscopy.

Dr. Belkin's publication record is excellent. Since joining the faculty at UT Austin, he has published 29 refereed journal publications in journals with high impact factors, including *Nature Communications*, *Applied Physics Letters*, and *IEEE Journals*. His career total is 56 journal papers. Dr. Belkin holds three patents and has submitted eight additional patent applications.

Dr. Belkin has secured research funding from highly competitive federal (NSF, DOD, DOE), state, and foundation programs. He serves as principal investigator on eight of these projects and co-PI on four. Total funding in rank is over $3.9 million and his share is nearly $2.5 million. Dr. Belkin's research impact has been recognized by several prestigious young investigator awards (Air Force Office of Sponsored Research, National Science Foundation, Texas Higher Education Coordinating Board, and Defense Advanced Research Projects Agency).

The external reviewers uniformly recognized the impact of Dr. Belkin's work in the area of quantum cascade lasers (QCL) for addressing high temperature operation and broadband tenability, and the use of QCLs to increase the spatial resolution in molecular spectroscopy:

Dr. James Coleman (University of Illinois at Urbana Champaign, NAE) writes, "For his research, Prof. Belkin has become a well-known and prolific contributor to the area of quantum cascade lasers. To be very clear, I am intending to send the message that the bar is set very high and Prof. Belkin is answering the challenge very well. He is bright, creative, and prolific."

Dr. Marlan O. Scully (Texas A&M University, NAS) writes, "In a short time Misha was able to build a highly-successful research group and, in my opinion, he is now the innovative and most accomplished scientist among his peers in the area of mid-infrared and THz photonics. I also consider Misha to be one of the most successful young scientists in photonics area in general."

Dr. Qing Hu (Massachusetts Institute of Technology) writes, "Dr. Belkin's group has developed a room-temperature THz source with ~0.1 mW and a broad tuning range of several THz … This is a significant development which could lead to compact THz sources with broad frequency coverage."

Dr. Dan Botez (University of Wisconsin-Madison) writes, "…a highly intelligent scientist possessed of a no-nonsense attitude of implementing new device concepts not only for achieving scientific breakthroughs but also for realizing novel devices of practical use. The future looks bright for Misha Belkin. Not only is he making breakthroughs in two fields (i.e., THz QCLs and molecular spectroscopy), but he has already positioned himself well for making significant contributions in the hot new applied-physics fields of plasmonics and metamaterials."

Advising and Student Mentoring

Dr. Belkin has graduated one PhD student and one MS student at UT. He is currently supervising four PhD students, three MS students, and one postdoctoral scholar.

Dr. Belkin also participates in the UTeachEngineering MA program in Science, Technology, Engineering, and Mathematics Education as a summer research supervisor. A high school teacher is performing MS thesis research in Dr. Belkin's laboratory through this program.

University Service

Dr. Belkin serves as the coordinator for the solid-state electronics graduate program in the Department of Electrical and Computer Engineering. In this capacity, he oversees the recruitment and admission of new graduate students and the PhD qualifying exams. In addition, he serves on the transition committee, which is managing the transition of the department from their existing facilities to the new Engineering Education and Research Center.

Professional Service

Dr. Belkin is currently serving as a co-chair of the 12th International Conference on Intersubband Transitions in Quantum Wells. He has also served on a number of conference program committees for international conferences and technical meetings. He currently serves as the chair of the Central Texas Chapter of the IEEE Photonics Society.

Other Evidence of Merit or Recognition

Dr. Belkin has been recognized by a number of competitive young investigator awards for his research potential and accomplishments. These include AFOSR young investigator research program award (2009), NSF CAREER award (2012), DARPA young faculty award (2012), and the Norman Hackerman early career

investigator award (2012). One of the references, Dr. James Coleman (NAE member) writes "Most young faculty would be delighted to receive one of these awards and Prof. Belkin has won four!"

Overall Assessment

Dr. Belkin has made several notable advances in the areas of novel optoelectronic devices and photonic systems operating in the mid-infrared and terahertz spectra. He has secured research funding from highly competitive federal and non-federal sources. External letters uniformly support his tenure and promotion and indicate that he has become a leader in his field of research with a productivity and impact significantly above his peers.

Accordingly, I am pleased to provide a strong recommendation to promote Mikhail Belkin to associate professor with tenure.

Sharon L. Wood, Interim Dean
31 October 2013

COCKRELL SCHOOL OF ENGINEERING
THE UNIVERSITY OF TEXAS AT AUSTIN

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1 University Station C0803 • Austin, Texas 78712-0240 • (512) 471-6179 • Fax (512) 471-3652

September 30, 2013

Chair's letter in support of the promotion of Prof. Mikhail Belkin to the rank of associate professor with tenure

Prof. Belkin joined the Department of Electrical and Computer Engineering in August 2008. Mikhail ("Misha") made seminal contributions to mid-infrared and terahertz lightwave technology before coming to UT and while at UT. In particular, he has emerged as a rising star in mid-infrared and terahertz optoelectronics while at UT. The Budget Council recognized his strong accomplishments and determined that he meets all expectations for promotion at the premier departments of Electrical and Computer Engineering in the nation by a vote of 27 YES, 0 NO and 0 ABSTAIN. Our associate professors voted 9 YES, 0 NO and 0 ABSTAIN in support of promotion.

Teaching

Prof. Belkin is a good teacher with average instructor scores in required undergraduate classes ranging from 3.5 to 3.8 and strong instructor scores in graduate courses ranging from 4.0 to 5.0. Students and his peers note that he is an excellent instructor who is able to simplify difficult concepts. He uses carefully prepared PowerPoint slides and makes them available to the students. Students also note that he is fair, and that the problem-solving sessions in the classes he teaches help them with homework.

I also note that Prof. Belkin has developed two new graduate classes on optoelectronics and nonlinear optics. The latter class attracts students from many other departments and is an essential introduction to the topic for anyone, regardless of major.

Research

Since joining UT in 2010, I have had the privilege of witnessing two major breakthroughs by Prof. Belkin. In particular, I was most excited by Prof. Belkin's recent work on room temperature terahertz semiconductor laser sources. Many top researchers have worked for over a decade on clever schemes for producing terahertz semiconductor lasers that can operate at room temperature but have failed to conceive any practical device. In his landmark 2012 and 2013 papers published in some of the most prestigious journals, Prof. Belkin demonstrated the first solid-state, room temperature, single mode, terahertz source quantum cascade laser source with an output frequency tunable over a very wide band that can be mass-produced at existing semiconductor laser foundries and provides more than a tenth of a milliwatt power. The significance of this work cannot be overstated, as mentioned in all of the reference letters we have received. Indeed, Prof. Faist (ETH, Zurich) notes that "The results have the potential to revolutionize the field" while Prof. Hu (MIT) states that Misha "produced laser devices with

record performance. ... His greatest contribution, in my opinion, is the development of room-temperature and broadly tunable THz sources based on intracavity DFG."

His recent work on subwavelength-resolution microscopy is no less ingenious and impressive. By using mid-infrared quantum cascade lasers for sample excitation and detecting minute forces produced by excited sample molecules on an atomic force microscope tip, he demonstrated mid-infrared molecular spectroscopy in ambient conditions with record 30 nm sub-monolayer sensitivity and spatial resolution in infrared molecular spectroscopy measurements. As Prof. Botez (UW-Madison and a recipient of the Holonyak Award from the Optical Society of America) notes "The exciting potential that Prof. Belkin's microscopy technique holds is the ability to do spectroscopy of single molecules, which, in turn, would open a whole new area of research in molecular physics as well as a multitude of practical applications."

As noted by all reference writers, Prof. Belkin had made seminal contributions to quantum cascade lasers while at Harvard as a postdoc and to nonlinear optics in his PhD work at Berkeley.

Prof. Belkin is very well funded by highly competitive peer-reviewed grants from NSF and DOD. He has received an NSF Career Award, an AFOSR Young Investigator Award and a DARPA Young Faculty Award. I expect his funding to increase even further as a result of his breakthrough inventions in the last three years.

Our department has adopted the practice of comparing each colleague with his or her most prominent peers at the first tier departments in Electrical and Computer Engineering, such as MIT, Stanford, the University of California Berkeley, the University of Illinois Urbana-Champaign (UIUC), Georgia Tech, Caltech and Princeton. In the case of Misha, I am tempted not to provide a comparison since professor Coleman (UIUC and NAE member) provided in his letter a very compelling comparison of Misha with peers of all ages when he wrote "For example, there are incredible senior scientists such as Capasso and Gmachl (who are among Prof. Belkin's collaborators and mentors) and a host of truly exceptional junior scientists in academia such as Ben Williams at UCLA, Alexandra Boltesseva at Purdue, and Dan Wasserman at Illinois. Prof. Belkin is as strong as all of the young people I have mentioned here and on a clear vector to equaling the career of Gmachl and potentially approaching that of Capasso. To be very clear, I am intending to send the message that the bar is set very high and Prof. Belkin is answering the challenge very well." To understand the full significance of this comment, one needs to know that Prof. Capasso is a member of the National Academy of Sciences, the National Academy of Engineering, the American Academy of Arts and Sciences, the European Academy of Sciences and holds an honorary membership in the Franklin Institute. The citation for a recent international award he received described him as "one the most creative and influential applied physicists in the world." Prof. Gmachl holds an endowed chair at Princeton.

Nevertheless, and for completeness sake, I will compare Misha with Associate Prof. Nicholas Fang (MIT), Prof. Jamie Phillips (Michigan) and Associate Prof. Farhan Rana (Cornell). Profs. Fang, Phillips and Rana were recently promoted at top 10 engineering departments at elite universities. The comparison shows that Misha is significantly more productive than Fang and Rana at the time of their promotion and as productive as Phillips. His current H index is comparable or superior to these three professors even though he is younger. He is as well funded if not better funded than all three of them. I also would like to reiterate the significance of his recent breakthroughs as evidenced by the large number of invited talks he has given at the most prestigious conferences in the field and at well-known universities in the US and Europe. Almost all letter writers gave detailed comparisons between Misha and other junior scientists and have stated unequivocally that he is one of the strongest junior scientist in his field, with several mentioning, in particular, that he is much stronger than Prof. Williams at UCLA.

Service

Misha has provided excellent service to both UT and the profession. Details can be found in his resume and the budget council statement. I will note in particular that Misha has played a leadership role in acquiring key equipment at MRC that is essential for the research of his colleagues and himself.

Summary

Misha is a good teacher and, in my opinion, a rising international star in photonics and nanostructured optoelectronics. He has served UT and his profession well. I strongly endorse his promotion to associate professor with tenure.

Sincerely,

Prof. Ahmed H. Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Department of Electrical and Computer Engineering

Electrical and Computer Engineering Revised September 18, 2013

THE UNIVERSITY OF TEXAS AT AUSTIN
Cockrell School of Engineering
Standard Resume

FULL NAME: Mikhail A. Belkin **TITLE:** Assistant Professor

DEPARTMENT: Electrical and Computer Engineering

EDUCATION:

University of California at Berkeley	Physics	Ph.D.	May 2004
University of California at Berkeley	Physics	M.A.	December 2000
Moscow Institute of Physics and Technology	Applied Physics and Mathematics	B. Sc.	June 1998

PROFESSIONAL REGISTRATION:

CURRENT AND PREVIOUS ACADEMIC POSITIONS:

University of Texas at Austin	Asst. Professor	Fall 2008 - present

OTHER PROFESSIONAL EXPERIENCE:

School of Engineering and Applied Sciences, Harvard University	Research Associate	August 2006 - August 2008
School of Engineering and Applied Sciences, Harvard University	Postdoctoral Fellow	August 2004 - August 2006

CONSULTING:

HONORS AND AWARDS:

2012 - DARPA Young Faculty Award
2012 - National Science Foundation CAREER Award
2012 - Norman Hackerman Advanced Research Program Award for Early Career Investigators
2012 - IEEE Senior Member
2009 - AFOSR Young Investigator Research Program Award
2004 - Los Alamos National Laboratory Director's Postdoctoral Fellowship (declined)
1998 - University of California at Berkeley graduate fellowship

MEMBERSHIPS IN PROFESSIONAL AND HONORARY SOCIETIES:

- Institute of Electrical and Electronics Engineers (IEEE, Senior Member)
- Optical Society of America (OSA, Life Member)
- International Society for Optics and Photonics (SPIE, Life Member)

UNIVERSITY COMMITTEE ASSIGNMENTS:

Departmental-	Member, ECE Seminars Committee	2/2013 - present
	ECE Solid-State Electronics Area Coordinator	10/2011 - present
	Member, ECE Transition Committee	12/2010 - present

PROFESSIONAL SOCIETY AND MAJOR GOVERNMENTAL COMMITTEES:

- Co-chair, The 12th International Conference on Intersubband Transitions in Quantum Wells (September 2013)
- Program committee member for
  - Semiconductor Laser section for the 2014 Conference on Lasers and Electro-Optics (CLEO)
  - The 35th International Conference on Infrared, Millimeter and Terahertz Waves (2011)
  - The 11th International Conference on Intersubband Transitions in Quantum Wells (2011)
  - IEEE Photonics Society topical meeting "Advances in Terahertz Devices and Applications" (2010)
  - The 10th International Conference on Intersubband Transitions in Quantum Wells (2009)
- Chair, IEEE Photonics Society Central Texas Chapter (2010 – present)
- Regular contributor to the OSA Spotlight on Optics
- Proposal panel reviewer for the NSF Electrical, Communications and Cyber Systems Division
- Proposal reviewer for Swiss National Science Foundation, French National Research Agency, and Qatar National Research Fund
- Reviewer for Nature Photonics, Nature Communications, Physical Review Letters, Applied Physics Letters, Optics Letters, Optics Express, IEEE Journal of Quantum Electronics, IEEE Journal of Selected Topics in Quantum Electronics, IEEE Photonics Technology Letters, Laser & Photonics Reviews, Optics Communications, Microelectronic Engineering, Journal of Physical Chemistry

PUBLICATIONS:

Google Scholar link: http://scholar.google.com/citations?user=ciL9ZFcAAAAJ
Thomson Reuters Researcher ID link: http://www.researcherid.com/rid/E-9041-2013

A. Refereed Archival Journal Publications

1. K. Vijayraghavan, M. Jang, A. Jiang, X. Wang, M. Troccoli, and M.A. Belkin, "Room-temperature terahertz sources with MOVPE grown quantum cascade lasers," under review (2013).
2. F. Lu, M. Jin, and M.A. Belkin, "Mid-infrared molecular force spectroscopy," under review (2013).
3. S. Suchalkin, G. Belenky, T. Hosoda, S. Jung, and M.A. Belkin, "Distributed Feedback Quantum Cascade Laser with optically tunable emission frequency," *Appl. Phys. Lett.* **103(4),** 041120-1 – 03112-3 (July 2013). http://dx.doi.org/10.1063/1.4816592
4. K. Vijayraghavan, Y. Jiang, M. Jang, A. Jiang, K. Choutagunta, A. Vizbaras, F. Demmerle, G. Boehm, M. C. Amann, and M. A. Belkin, "Broadly tunable terahertz generation in mid-infrared quantum cascade lasers," *Nature Comm.* **4,** 2021-1 – 2021-7 (June 2013). http://dx.doi.org/10.1038/ncomms3021
5. S. Suchalkin, S. Jung, R. Tober, M.A. Belkin, and G. Belenky, "Optically tunable long wavelength infrared quantum cascade laser operated at room temperature," *Appl. Phys. Lett.* **102(1),** 011125-1 – 011125-4 (Jan. 2013). http://dx.doi.org/10.1063/1.4774267
6. M. Jang, S. Suchalkin, and M.A. Belkin, "Mid-infrared quantum cascade lasers with electrical control of the emission frequency," *IEEE J. of Quantum Electron.* **49(1),** 60-64 (Jan. 2013). http://dx.doi.org/10.1109/JQE.2012.2227954
7. K. Vijayraghavan, R.W. Adams, A. Vizbaras, M. Jang, C. Grasse, G. Boehm, M.C. Amann, and M.A. Belkin, "Terahertz sources based on Čerenkov difference-frequency generation in quantum cascade lasers," *Appl. Phys. Lett.* **100(25),** 251104-1 – 251104-4 (June 2012). http://dx.doi.org/10.1063/1.4729042
8. Y. Zhao, M.A. Belkin, and A. Alu, "Twisted optical metamaterials for planarized, ultrathin, broadband circular polarizers," *Nature Comm.* **3,** 870-1 – 870-7 (May 2012). http://dx.doi.org/10.1038/ncomms1877
9. A. Matyas, R. Chashmahcharagh, I. Kovacs, P. Lugli, K. Vijayraghavan, M.A. Belkin, and C. Jirauschek, "Improved terahertz quantum cascade laser with variable height barriers," *J. Appl. Phys.* **111(10),** 103106-1 – 103106-6 (May 2012). http://dx.doi.org/10.1063/1.4719071
10. A. Vizbaras, M. Anders, C. Grasse, S. Katz, G. Boehm, R. Meyer, M.A. Belkin, and M.-C. Amann, "Short-wavelength InP quantum cascade laser sources by quasi-phase-matched intracavity second-

harmonic generation," *Phys. Status Solidi C* **9(2),** 298-301 (Feb. 2012). http://dx.doi.org/10.1002/pssc.201100257

11. Y. Chassagneux, Q.J. Wang, S.P. Khanna, E. Strupiechonski, J. Coudevylle, E.H. Linfield, A.G. Davies, F. Capasso, M.A. Belkin, and R. Colombelli, "Limiting factors to the temperature performance of THz quantum cascade lasers based on the resonant-phonon depopulation scheme," *IEEE Trans. Terahertz Sci. Technol.* **2(1),** 83-92 (Jan. 2012). **(invited paper)** http://dx.doi.org/10.1109/TTHZ.2011.2177176
12. F. Lu and M.A. Belkin, "Infrared absorption nano-spectroscopy using sample photoexpansion induced by tunable quantum cascade lasers," *Optics Express* **19(21),** 19942-19947 (Sept. 2011). http://dx.doi.org/10.1364/OE.19.019942
13. J. Lee, F. Lu, and M.A. Belkin, "Broadly wavelength tunable bandpass filters based on long-range surface plasmon polaritons," *Opt. Lett.* **36(19),** 3744-3746 (Sept. 2011). http://dx.doi.org/10.1364/OL.36.003744
14. M. Jang, X. Wang, R.W. Adams, M. Troccoli, and M.A. Belkin, "Room-temperature 2.95μm quantum cascade laser sources based on intra-cavity frequency doubling," *Electron. Lett.* **47(11),** 667-668 (May 2011). http://dx.doi.org/10.1049/el.2011.0753
15. A. Vizbaras, M. Anders, S. Katz, C. Grasse, G. Boehm, R. Meyer, M.A. Belkin, and M.-C. Amann, "Room-temperature lambda=2.7μm quantum cascade laser sources based on intracavity second-harmonic generation," *IEEE J. Quantum Electron.* **47(5),** 691-697 (May 2011). http://dx.doi.org/10.1109/JQE.2011.2109372
16. R.W. Adams, A. Vizbaras, M. Jang, C. Grasse, S. Katz, G. Boehm, M.C. Amann, and M.A. Belkin, "Terahertz sources based on intracavity frequency mixing in mid-infrared quantum cascade lasers with passive nonlinear sections," *Appl. Phys. Lett.* **98(15),** 151114-1 – 151114-3 (Apr. 2011). http://dx.doi.org/10.1063/1.3579260
17. M. Jang, R.W. Adams, J.X. Chen, W.O. Charles, C. Gmachl, L.W. Cheng, F.-S. Choa, and M.A. Belkin, "Room-temperature operation of 3.6μm $In_{0.53}Ga_{0.47}As/Al_{0.48}In_{0.52}As$ quantum cascade laser sources based on intracavity second harmonic generation," *Appl. Phys. Lett.* **97(14),** 141103-1 – 141103-3 (Oct. 2010). http://dx.doi.org/10.1063/1.3491219
18. R.W. Adams, K. Vijayraghavan, Q.J. Wang, J. Fan, F. Capasso, S.P. Khanna, A.G. Davies, E.H. Linfield, and M.A. Belkin, "$GaAs/Al_{0.15}Ga_{0.85}As$ terahertz quantum cascade lasers with double-phonon resonant depopulation operating up to 172 K," *Appl. Phys. Lett.* **97(13),** 131111-1 – 131111-3 (Oct. 2010). http://dx.doi.org/10.1063/1.3496035
19. V.-M. Gkortsas, C. Wang, L. Kuznetsova, L. Diehl, A. Gordon, C. Jirauschek, M.A. Belkin, A. Belyanin, F. Capasso, and F.X. Kartner, "Dynamics of actively mode-locked quantum cascade lasers," *Optics Express*, **18(13),** 13616-13630 (June 2010). http://dx.doi.org/10.1364/OE.18.013616
20. A. Matyas, M.A. Belkin, P. Lugli, and C. Jirauschek, "Temperature performance analysis of terahertz quantum cascade lasers: vertical versus diagonal designs," *Appl. Phys. Lett.* **96(20),** 201110-1 – 201110-3 (May 2010). http://dx.doi.org/10.1063/1.3430741
21. Q.J. Wang, C. Yan, L. Diehl, M. Hentschel, J. Wiersig, N. Yu, C. Pflugl, M.A. Belkin, T. Edamura, M. Yamanishi, H. Kan, and F. Capasso, "Deformed microcavity quantum cascade lasers with directional emission," *New J. Phys.* **11,** 125018-1 – 125018-17 (Dec. 2009). http://dx.doi.org/10.1088/1367-2630/11/12/125018
22. N. Yu, M.A. Kats, C. Pflugl, M. Geiser, Q.J. Wang, M.A. Belkin, F. Capasso, M. Fischer, A. Wittmann, J. Faist, T. Edamura, S. Furuta, M. Yamanishi, and H. Kan, "Multi-beam multi-wavelength semiconductor lasers," *Appl. Phys. Lett.* **95(16),** 161108-1 – 161108-3 (Oct. 2009). http://dx.doi.org/10.1063/1.3253713
23. B.G. Lee, J. Kansky, A.K. Goyal, C. Pflugl, L. Diehl, M.A. Belkin, A. Sanchez, and F. Capasso, "Beam combining of quantum cascade laser arrays," *Optics Express* **17(18),** 16216-16224 (Aug. 2009). http://dx.doi.org/10.1364/OE.17.016216
24. C.Y. Wang, L. Kuznetsova, V.M. Gkortsas, L. Diehl, F.X. Kärtner, M.A. Belkin, A. Belyanin, X. Li, D. Ham, H. Schneider, P. Grant, C.Y. Song, S. Haffouz, Z.R. Wasilewski, H.C. Liu, and F. Capasso, "Mode-locked pulses from mid-infrared quantum cascade lasers," *Optics Express* **17(15),** 12929-12943 (July 2009). http://dx.doi.org/10.1364/OE.17.012929
25. B.G. Lee, H.A. Zhang, C. Pflügl, L. Diehl, M.A. Belkin, M. Fischer, A. Wittmann, J. Faist, and F. Capasso, "Broadband distributed-feedback quantum cascade laser array operating from 8.0 to

9.8μm," *IEEE Photon. Technol. Lett.* **21(13),** 914-916 (July 2009). http://dx.doi.org/10.1109/LPT.2009.2020440

26. C. Yan, Q.J. Wang, L. Diehl, M. Hentschel, J. Wiersig, N. Yu, C. Pflügl, F. Capasso, M.A. Belkin, T. Edamura, M. Yamanishi, and H. Kan, "Directional emission and universal far-field behavior from semiconductor lasers with limaçon-shaped microcavity," *Appl. Phys. Lett.* **94(25),** 251101-1 – 251101-3 (June 2009). http://dx.doi.org/10.1063/1.3153276
27. M. Hentschel, T.-Y. Kwon, M.A. Belkin, R. Audet, and F. Capasso, "Angular emission characteristics of quantum cascade spiral microlasers," *Optics Express* **17(12),** 10335-10343 (June 2009). http://dx.doi.org/10.1364/OE.17.010335
28. M.A. Belkin, Q.J. Wang, C. Pfügl, A. Belyanin, S.P. Khanna, E.H. Linfield, and F. Capasso, "High temperature operation of terahertz quantum cascade laser sources," *IEEE J. Sel. Top. Quantum Electron.* **15(3),** 952-967 (May-June 2009). (**Invited paper**) http://dx.doi.org/10.1109/JSTQE.2009.2013183
29. B.G. Lee, M.A. Belkin, C. Pflügl, L. Diehl, H.A. Zhang, R.M. Audet, J. MacArthur, D.P. Bour, S.W. Corzine, G.E. Höfler, and F. Capasso, "DFB quantum cascade laser arrays," *IEEE J. Quantum Electron.* **45(5),** 554-565 (May 2009). http://dx.doi.org/10.1109/JQE.2009.2013175
30. M. Troccoli, L. Diehl, D.P. Bour, S.W. Corzine, N. Yu, C.Y. Wang, M.A. Belkin, G. Höfler, R. Lewicki, G. Wysocki, F.K. Tittel, and F. Capasso, "High-performance quantum cascade lasers grown by metal-organic vapor phase epitaxy and their applications to trace gas sensing," *IEEE J. of Lightwave Technology* **26(21),** 3534-3555 (Nov. 2008). http://dx.doi.org/10.1109/JLT.2008.925056
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41. J. Fan, M. Belkin, F. Capasso, S. Khanna, M. Lachab, G. Davies, and E. Linfield, "Wide ridge low-divergence metal-metal terahertz quantum cascade lasers," *2008 Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference* **1-9,** 728-729, San Jose, CA (May 2008). http://www.opticsinfobase.org/abstract.cfm?URI=CLEO-2008-CMV3
42. M.A. Belkin, R.M. Audet, J.A. Fan, F. Capasso, E. Narimanov, D. Bour, S. Corzine, J. Zhu, and G. Hofler, "Current injection spiral-shaped chaotic microcavity quantum cascade lasers," *2007 Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference* **1-5,** 496-497, Baltimore, MD (May 2007). http://www.opticsinfobase.org/abstract.cfm?URI=CLEO-2007-CTuE4
43. F. Xie, D. Smith, V.R. Chaganti, A. Belyanin, D. Wasserman, C. Gmachl, J. Kono, M. Belkin, and F. Capasso, "Nonlinear quantum cascade lasers: toward broad tunability and short-wavelength operation," *2007 Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference* **1-5,** 612-613, Baltimore, MD (May 2007). http://www.opticsinfobase.org/abstract.cfm?URI=CLEO-2007-CTuO6
44. J. Fan, M. Belkin, F. Capasso, S. Khanna, M. Lachab, G. Davies, and E. Linfield, "Low-divergence surface-emitting terahertz quantum cascade lasers," *2007 Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference* **1-5,** 951-952, Baltimore, MD (May 2007). http://www.opticsinfobase.org/abstract.cfm?URI=CLEO-2007-CWG5
45. B.G. Lee, R. Audet, J. MacArthur, M. Belkin, L. Diehl, C. Pflugl, F. Capasso, D. Bour, S. Corzine, J. Xhu, and G. Hoefler, "Broadly tunable single-mode quantum cascade laser sources," *2007 Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference* **1-5,** 1541-1542, Baltimore, MD (May 2007). http://www.opticsinfobase.org/abstract.cfm?URI=CLEO-2007-CFB4

C. Other Major Publications

1. B.G. Lee, M.A. Belkin, and F. Capasso, "Array of tiny quantum cascade lasers provides tunable mid-IR output," *Photonics Spectra* **42,** 70 (May 2008). http://www.photonics.com/Article.aspx?AID=33534

ORAL PRESENTATIONS:

1. *Forthcoming:* M.A. Belkin, K. Vijayraghavan, Y. Jiang, S. Jung, F. Demmerle, G. Boehm, and M. Amann, "Progress in THz difference-frequency quantum cascade laser sources," SPIE Photonics West, San Francisco, CA, February 2014. (**Invited talk**).
2. *Forthcoming:* M. A. Belkin, Y. Jiang, K. Vijayraghavan, S. Jung, F. Demmerle, G. Boehm, and M. Amann, "Broadly tunable terahertz quantum cascade laser sources," Mid-infrared Coherent Sources Optical Society of America Topical Meeting, Paris, France, October 2013. (**Invited talk**)
3. *Forthcoming:* M. A. Belkin, Y. Jiang, K. Vijayraghavan, F. Demmerle, G. Boehm, and M. Amann, "Broadly-tunable room temperature terahertz quantum cascade laser sources: devices and applications," SCIX 2013 Conference, Milwaukee, WI, September-October 2013. (**Invited talk**)
4. *Forthcoming:* F. Lu, M. Jin, and M.A. Belkin "Mid-infrared vibrational nanospectroscopy via direct molecular force detection," SCIX 2013 Conference, Milwaukee, WI, September-October 2013. (**Invited talk**)

5. *Forthcoming:* J. Lee, P.Y. Chen, C. Argyropoulos, A. Alu, and M.A. Belkin, "Metamaterials based on intersubband polaritons," The 7th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics, Bordeaux, France, September 2013. (**Invited talk**)
6. M.A. Belkin, "High performance broadly-tunable terahertz quantum cascade laser sources based on intra-cavity frequency mixing," The 21st International Symposium "Nanostructures: physics and technology," Saint Petersburg, Russia, June 2013. (**Invited talk**)
7. M. A. Belkin, K. Vijayraghavan, Y. Jiang, A. Jiang, F. Demmerle, G. Boehm, and M. Amann, "Room-temperature quantum cascade laser sources of terahertz radiation," CLEO-QELS, San Jose, CA, June 2013. (**Invited talk**)
8. M.A. Belkin, "Nanoscale mid-infrared vibrational spectroscopy with monolayer sensitivity," 96th Canadian Chemistry Conference, Quebec City, Canada, May 30, 2013. (**Invited talk**)
9. M.A. Belkin, "Broadly-tunable room-temperature THz quantum cascade laser sources," Electrical Engineering Seminar, University of Texas at Dallas, Richardson, TX, May 16, 2013. (**Seminar**)
10. M.A. Belkin, "Broadly-tunable room-temperature THz quantum cascade laser sources," Atomic, Molecular, and Optical Physics Seminar, Texas A&M University, College Station, TX, April 26, 2013. (**Seminar**)
11. M.A. Belkin, "Nanoscale infrared spectroscopy by detecting molecular forces," Electrical and Computer Engineering Seminar, University of Houston, Houston, TX, April 19, 2013. (**Seminar**)
12. M.A. Belkin, "Room-temperature electrically-pumped THz semiconductor sources," US-UK Workshop in Mid-IR to THz Technology and Applications, Edinburgh, UK, February 19, 2013. (**Invited talk**)
13. M.A. Belkin, K. Vijayraghavan, A. Vizbaras, A. Jiang, F. Demmerle, G. Boehm, R. Meyer, M.-C. Amann, A. Matyas, R. Chashmahcharagh, P. Lugli, C. Jirauschek, and Z.R. Wasilewski, "THz quantum cascade lasers for operation above cryogenic temperatures," SPIE Photonics West, San Francisco, CA, February 6, 2013. (**Invited talk**).
14. M.A. Belkin, F. Lu, M. Jin, M. Salih, P. Dean, S.P. Khanna, L.H. Li, G. Davies, and E.H. Linfield, "Terahertz and mid-infrared photoexpansion nanospectroscopy," SPIE Photonics West, San Francisco, CA, February 6, 2013. (**Invited talk**)
15. M. Belkin, "Infrared vibrational nanospectroscopy by detecting molecular forces," Texas A&M University Institute for Quantum Science and Engineering Workshop, College Station, TX, January 16, 2013. (**Invited talk**)
16. M. Belkin, K. Vijayraghavan, F. Demmerle, M. Jang, A. Jiang, C. Grasse, and M.-C. Amann, "Room-temperature THz quantum cascade laser sources," Photonics Global Conference, Singapore, December 15, 2012. (**Invited talk**)
17. M.A. Belkin, "Nanoscale spectroscopy and plasmonics in infrared," Electrical Engineering Seminar, Nanyang Technological University, Singapore, December 12, 2012. (**Seminar**)
18. M.A. Belkin, "Room temperature terahertz quantum cascade laser sources," Physics Department Seminar, Fudan University, Shanghai, China, December 10, 2012. (**Seminar**)
19. M.A. Belkin, "Room-temperature THz quantum cascade laser sources," Electrical Engineering Department Seminar, University of Wisconsin at Madison, Madison, WI, November 19, 2012. (**Seminar**)
20. M.A. Belkin, "THz generation and nanoscale chemical imaging with quantum cascade lasers," Optical, Electronic, and Quantum Systems Seminar, University of Colorado at Boulder, Boulder, CO, October 12, 2012. (**Seminar**)
21. M. Belkin and F. Lu, "Tip-enhanced mid-infrared and terahertz photoexpansion nanospectroscopy," SciX conference, Kansas City, MO, October 1, 2012. (**Invited talk**)
22. M.A. Belkin, "THz generation and nanoscale chemical imaging with quantum cascade lasers," Institute of Fundamental Electronics, University of Paris – South, Orsay, France, September 12, 2012. (**Seminar**)
23. M.A. Belkin, "Nanoscale chemical imaging with quantum cascade lasers," Walter Schottky Institute, Technical University of Munich, Garching, Germany, September 6, 2012. (**Seminar**)
24. M.A. Belkin, "THz generation and nanoscale chemical imaging with quantum cascade lasers," Department of Electrical Engineering, University of California – Los Angeles, Los Angeles, CA, August 14, 2012. (**Seminar**)
25. M.A. Belkin, "THz generation and nanoscale chemical imaging with quantum cascade lasers," The International Laser Center, Moscow State University, Moscow, Russia, June 8, 2012. (**Seminar**)

26. M.A. Belkin, "Terahertz quantum cascade lasers: Progress towards room-temperature operation," Defense Science Research Council (DSRC) workshop on "Solid state devices with vacuum tube-like electron dynamics for high-power terahertz generation," Arlington, VA, February 2, 2012. (**Invited talk**)
27. M.A. Belkin, "Nanoscale spectroscopy and plasmonics in infrared," Condensed Matter Seminar, Physics Department, Purdue University, West Lafayette, IN, January 13, 2012. **(Seminar)**
28. M.A. Belkin, "Nanoscale spectroscopy and plasmonics in infrared," Nanoelectronics and Nanophotonics Seminar, Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, Urbana, IL, January 12, 2012. (**Seminar**)
29. M.A. Belkin, "Nanoscale chemical imaging and THz generation using quantum cascade lasers," Air Force Research Laboratory, Brooks City-Base, TX, October 2011. (**Seminar**)
30. M.A. Belkin, "Nanoscale imaging and plasmonic devices in infrared," Princeton Institute for the Science and Technology of Materials, Princeton University, Princeton, NJ, October 2011. (**Seminar**)
31. M.A. Belkin and F. Lu, "Infrared absorption nano-spectroscopy with quantum cascade lasers," Federation of Analytical Chemistry and Spectroscopy Societies (FACSS) Conference, Reno, NV, October 2011. (**Invited talk**)
32. M.A. Belkin, "Nanoscale imaging, optoelectronics, and plasmonics in mid-infrared," Schottky Seminar, Walter Schottky Institute, Technical University of Munich, Garching, Germany, July 2011. **(Seminar)**
33. M.A. Belkin, "Nanoscale imaging, optoelectronics, and plasmonics in mid-infrared," Photonics Seminar, Technical University of Vienna, Vienna, Austria, July 2011. (**Seminar**)
34. M.A. Belkin, "Nanoscale imaging, optoelectronics, and plasmonics in mid-infrared," Laser Seminar, ETH Zurich, Switzerland, July 2011. (**Seminar**)
35. M.A. Belkin, M. Jang, R.W. Adams, J. X. Chen, W. O. Charles, C. Gmachl, X. Wang, M. Troccoli, A. Vizbaras, M. Anders, S. Katz, C. Grasse, G. Boehm, R. Meyer, M.C. Amann, L. W. Cheng, and F.-S. Choa, "2.6-3.6 micron InGaAs/AlInAs quantum cascade laser sources based on intra-cavity second harmonic generation," 20th International Laser Physics Workshop, Sarajevo, Bosnia and Herzegovina, July 2011. (**Invited talk**)
36. M.A. Belkin, M. Jang, R.W. Adams, J.X. Chen, W.O. Charles, C. Gmachl, L.W. Cheng, F.-S. Choa, X. Wang, M. Troccoli, A. Vizbaras, M. Anders, C. Grasse, and M.-C. Amann, "InGaAs/AlInAs quantum cascade laser sources based on intra-cavity second harmonic generation emitting in 2.6-3.6 micron range," SPIE Photonics West, San Francisco, CA, January 2011. (**Invited talk**)
37. M.A. Belkin, M. Jang, R.W. Adams, K. Vijayraghavan, J. X. Chen, W.O. Charles, C. Gmachl, L.W. Cheng, F.-S. Choa, A. Vizbaras, M. Anders, S. Katz, C. Grasse, G. Boehm, R. Meyer, M.C. Amann, X. Wang, and M. Troccoli, "$\lambda \approx 2.6\text{-}3.6\mu m$ InGaAs/AlInAs quantum cascade laser sources based on intra-cavity second harmonic generation," 41st Winter Colloquium on The Physics of Quantum Electronics, Snowbird, UT, January 2011. (**Invited talk**)
38. M.A. Belkin and F. Lu, "Photoacoustic microscopy with quantum cascade lasers," International Quantum Cascade Lasers School and Workshop, Florence, Italy, September 2010. (**Invited talk**)
39. M.A. Belkin, "Towards room-temperature quantum cascade lasers in Terahertz," Condensed Matter Seminar, Physics Department, The University of Texas at Austin, Austin, TX, April 2010. (**Seminar**)
40. M.A. Belkin, R. W. Adams, A. Vizbaras, M. Jang, C. Grasse, S. Katz, G. Boehm, and M.C. Amann, "THz quantum cascade laser sources for room-temperature operation," 40th Winter Colloquium on The Physics of Quantum Electronics, Snowbird, UT, January 2010. (**Invited talk**)
41. M.A. Belkin, "Towards room-temperature terahertz quantum cascade laser sources," Physics Department Seminar, State University of New York at Stony Brook, Stony Brook, NY, November 2009. **(Seminar)**
42. M.A. Belkin, "Terahertz quantum cascade laser sources for high temperature operation," CLEO-Europe, Munich, Germany, June 2009. **(Invited talk)**
43. M.A. Belkin, A. Belyanin, S. Khanna, G. Davies, E. Linfield, and J. Faist, "High temperature operation of quantum cascade laser sources," IEEE Photonics Society International Conference on Indium Phosphate and Related Materials, Newport Beach, CA, May 2009. **(Invited talk)**
44. M.A. Belkin, F. Capasso, and A. Belyanin, "High temperature operation of terahertz quantum cascade laser sources," Materials Research Society Spring Meeting, San Francisco, CA, April 2009. **(Invited talk)**
45. M.A. Belkin, "Quantum cascade lasers: from systems for chemical sensing to nonlinear optics in terahertz," The Center for Nanotechnology Seminar, University of Washington, Seattle, WA, October 2008. **(Seminar)**

46. M.A. Belkin, "Designing THz QCL sources for operation above cryogenic temperatures," International Quantum Cascade Lasers School and Workshop, Monte Verita, Switzerland, September 2008. **(Invited talk)**
47. M.A. Belkin, "Towards room-temperature terahertz quantum cascade laser sources," NSF Research Center Mid-Infrared Technologies for Health and the Environment (MIRTHE) workshop, Baltimore, MD, August 2008. **(Tutorial)**
48. M.A. Belkin, F. Capasso, A. Belyanin, F. Xie, M. Fischer, A. Wittmann, and J. Faist, "Room-temperature terahertz sources based on intra-cavity difference-frequency generation in mid-infrared quantum cascade lasers," 17th International Laser Physics Workshop, Trondheim, Norway, June-July 2008. **(Invited talk)**
49. M.A. Belkin, "Quantum cascade lasers – bridging the terahertz gap with semiconductor lasers," Photonics Center Seminar, University of Massachusetts at Lowell, Lowell, MA, June 2008. **(Seminar)**
50. M.A. Belkin, "Quantum cascade lasers – bridging the terahertz gap with semiconductor lasers," Department of Physics Seminar, Texas A&M University, College Station, TX, May 2008. **(Seminar)**
51. M.A. Belkin, "Quantum cascade lasers – bridging the terahertz gap with semiconductor lasers," Department of Electrical and Systems Engineering Seminar, University of Pennsylvania, Philadelphia, PA, April 2008. **(Seminar)**
52. M.A. Belkin, "Quantum cascade lasers – bridging the terahertz gap with semiconductor lasers," Department of Electrical and Computer Engineering Seminar, University of Texas, Austin, Austin, TX, April 2008. **(Seminar)**
53. M.A. Belkin, "Quantum cascade lasers – bridging the terahertz gap with semiconductor lasers," Department of Physics Seminar, Georgia Institute of Technology, Atlanta, GA, April 2008. **(Seminar)**
54. M.A. Belkin, "Quantum cascade lasers – bridging the terahertz gap with semiconductor lasers," College of Optics Seminar, University of Central Florida, Orlando, FL, March 2008. **(Seminar)**
55. M.A. Belkin, "Quantum cascade lasers – bridging the terahertz gap with semiconductor lasers," Department of Physics Seminar, Tufts University, Medford, MA, March 2008. **(Seminar)**
56. M.A. Belkin, "Quantum cascade lasers – bridging the terahertz gap with semiconductor lasers," Department of Physics Seminar, University of California at Davis, Davis, CA, February 2008. **(Seminar)**
57. M.A. Belkin, "Quantum cascade lasers – bridging the terahertz gap with semiconductor lasers," Department of Physics Seminar, Arizona State University, Tempe, AZ, February 2008. **(Seminar)**
58. M.A. Belkin, "THz quantum cascade laser sources for operation above cryogenic temperatures," Department Seminar, Department of Electrical and Computer Engineering, University of California, San Diego, CA, January 2008. **(Seminar)**
59. M.A. Belkin, A.A. Belyanin, and F. Capasso, "Terahertz source based on intracavity difference-frequency generation in quantum cascade lasers," SPIE Photonics West, San Jose, CA, January 2008. **(Invited talk)**
60. M.A. Belkin, "Novel intersubband THz sources for operation above cryogenic temperatures," 38th Winter Colloquium on The Physics of Quantum Electronics, Snowbird, UT, January 2008. **(Invited talk)**
61. M.A. Belkin, "Terahertz quantum cascade lasers sources for operation above cryogenic temperatures," School of Electronic and Electrical Engineering seminar, University of Leeds, U.K., September 2007. **(Seminar)**
62. M.A. Belkin, F. Capasso, A. Belyanin, and D.L. Sivco, "Terahertz quantum cascade laser source based on intra-cavity difference-frequency generation," CLEO-Europe, Munich, Germany, June 2007. **(Invited talk)**
63. M.A. Belkin, F. Capasso, A. Belyanin, and D.L. Sivco, "Terahertz difference-frequency generation in quantum cascade lasers," CLEO/QELS, Baltimore, MD, May 2007. **(Invited talk)**
64. M.A. Belkin, "New directions in quantum cascade lasers research: from nonlinear optics to mid-IR sensors for lab-on-a-chip," GE Global Research seminar, Niskayuna, NY, October 2006. **(Seminar)**
65. M.A. Belkin, "New directions in quantum cascade laser applications: from optofluidic lasers to plasmonic laser antennas," 2nd International Workshop on Quantum Cascade Lasers, Brindisi, Italy, September 2006. **(Invited talk)**
66. M.A. Belkin, "Sum-frequency spectroscopy as a novel probe of molecular chirality," Special Seminar, Los Alamos National Laboratory, Los Alamos, NM, June 2004. **(Seminar)**
67. M.A. Belkin, "Sum-frequency spectroscopy as a novel probe of molecular chirality," Atomic, Molecular and Optical Science Seminar, Physics Department, University of California at Berkeley, Berkeley, CA, April 2004. **(Seminar)**

68. M.A. Belkin, "The application of sum-frequency generation spectroscopy to study chirality," LEOS Moscow Chapter Seminar, International Laser Center of Moscow State University, Moscow, Russia, September 2003. **(Seminar)**
69. M.A. Belkin and Y.R. Shen, "Sum-frequency spectroscopy as a novel probe of molecular chirality," CLEO/QELS, Baltimore, MD, June 2003. **(Invited talk)**

PATENTS:

Issued patents

1. M.A. Belkin, B.G. Lee, R.M. Audet, J.B. MacArthur, L. Diehl, C. Pflügl, and F. Capasso, "Broadly tunable single-mode quantum cascade laser sources and sensors," U.S. patent number 7,826,509, issued November 2, 2010.
2. M.A. Belkin, F. Capasso, and A. Belyanin, "Methods and apparatus for generating terahertz radiation," U.S. patent number 7,974,325, issued July 5, 2011.
3. F. Capasso, B.G. Lee, C. Pflugl, L. Diehl, and M.A. Belkin, "Methods and apparatus for single-mode selection in quantum cascade lasers," U.S. Patent number 8,351,481, issued January 8, 2013.

Patent applications

1. C. Pflugl, B.G. Lee, L. Diehl, M.A. Belkin, F. Capasso, and T.J. Tague, Jr., "Spectrometers utilizing midinfrared ultra broadband high brightness light sources," U.S. patent application number 12/263,948, filed on November 3, 2008.
2. M.A. Belkin and W. Masselink, "Terahertz quantum cascade lasers," U.S. patent application number 13/148,459, filed on February 16, 2010.
3. M.A. Belkin, "Quantum cascade lasers (QCLs) configured to emit light having a wavelength in the 2.5-3.8 micrometer band," U.S. patent application number 12/791,587, filed on June 1, 2010.
4. G. Belenky, J.D. Bruno, M.V. Kisin, S. Luryi, L. Shterengas, S. Suchalkin, R.L. Tober, and M. Belkin, "Quantum cascade lasers with electrically tunable emission wavelengths," U.S. patent application number 13/012,62, filed on January 24, 2011.
5. A. Goyal, B.G. Lee, C. Pfluegl, L. Diehl, M. Belkin, A. Sanchez-Rubio, and F. Capasso, "Wavelength combining of quantum cascade laser arrays," U.S. patent application number 13/197,058, filed on August 3, 2011.
6. M. Belkin, F. Lu, V.V. Yakovlev, C. Prater, and K. Kjoller, "High frequency deflection measurement of IR absorption," U.S. patent application number 13/307,464, filed on November 30, 2011.
7. M. Belkin and J. Lee, "Tunable optical filter utilizing a long-range surface plasmonic polariton waveguide to achieve a wide tuning range," U.S. patent application number 13/426,329, filed on March 21, 2012.
8. M.A. Belkin, R.W. Adams, A. Vizbaraz, M.-C. Amann, "Terahertz quantum cascade laser implementing a Čerenkov difference-frequency generation scheme," U.S. patent application number 13/949,379, filed on July 24, 2013.

GRANTS AND CONTRACTS:

Co-Investigators	Title	Agency	Grant Total	Grant Period
None	"Mid-infrared photoacoustic spectroscopy with nanometer resolution using quantum cascade lasers"	Welch Foundation	$150,000	6/1/09 – 5/31/12
Prof. Alexey Belyanin (co-PI, Texas A&M Univ.)	"COLLABORATIVE RESEARCH: Room-temperature terahertz semiconductor Raman lasers"	National Science Foundation	$414,987 (my share $324,987)	9/1/09 – 8/31/13
None	"Tunable Quantum Electronic Metamaterials for Mid-Infrared"	Air Force Office of Scientific Research	$359,178	4/1/10 – 3/31/13
Prof. Alexey Belyanin (co-PI, Texas A&M Univ.)	"Room-temperature electrically-pumped semiconductor sources of THz radiation"	Texas Higher Education Coordinating Board	$192,381 (my share $132,381)	7/1/10 – 8/31/13
Prof. Gregory Belenky (PI, SUNY at Stony Brook)	"COLLABORATIVE: Ultra-fast tunable quantum cascade lasers"	National Science Foundation	$454,949 (my share $224,759)	9/15/10 – 8/31/13
None	"CAREER: Terahertz semiconductor laser sources for operation above cryogenic temperatures"	National Science Foundation	$400,000	5/1/12 – 4/30/17
Dr. Craig Prater (Anasys Instruments)	"Resonance-Enhanced Infrared Nanospectroscopy (REINS) based on Atomic Force Microscopy and Quantum Cascade Lasers"	Department of Energy (Phase I STTR)	$150,000 (my share $90,000)	2/1/12 – 10/31/12
None	"Plasmonic-enhanced nanoscale mid-infrared microscopy with monolayer sensitivity"	Welch Foundation	$120,000	6/1/12 – 5/31/14
None	"Short-wavelength quantum cascade lasers with internal frequency doubling"	Texas Higher Education Coordinating Board	$80,000	7/1/12 – 8/31/14
Dr. Swapnajit Chakravarty (Omega Optics)	"Monolithic Photonic Crystal On-Chip Spectrometer for Laser Absorption Spectroscopy"	Army Research Office (Phase II SBIR)	$780,000 (my share $150,000)	08/27/12 – 05/02/14

Co-Investigators	Title	Agency	Grant Total	Grant Period
None	"Room-Temperature High-Power Terahertz Semiconductor Laser Sources"	Defense Advanced Research Projects Agency	$300,000	08/13/12 – 08/12/14
Dr. Craig Prater (Anasys Instruments)	"Resonance-Enhanced Infrared Nanospectroscopy (REINS) based on Atomic Force Microscopy and Quantum Cascade Lasers"	Department of Energy (Phase II STTR)	$500,000 (my share $150,000)	4/22/13 – 4/21/14

Total funding: $3,901,495 (my share $2,481,305)

PH.D. SUPERVISIONS COMPLETED:

Jang, Min	Dec. 2012	Quantum cascade laser sources based on intra-cavity frequency mixing	Electrical and Computer Engineering	The University of Texas at Austin

M.S. SUPERVISIONS COMPLETED:

Adams, Robert	Dec. 2011	Electrical and Computer Engineering	The University of Texas at Austin

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This document identifies co-authors and percentage contributions to each journal paper published in rank. Percentages refer only to group leaders, contributions of students and postdocs are combined with that of their group leader. Names of group leaders are indicated in bold in the authors list. In this document I focus on peer-reviewed journal contributions only, as conference abstracts do not necessarily add substantial information for the promotion process. The culture of my research area is that major research advances are published in journal articles, while conference proceedings typically report the same research results as presented at conferences.

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  - David P. Bour, Agilent Technologies, Inc., Santa Clara, CA
  - Yannick Chassagneux, University of Paris – Sud 11, Orsay, France
  - R. Chashmahcharagh, Technical University of Munich, Germany
  - William O. Charles, Princeton Unviersity, Princeton, NJ
  - J.X. Chen, Princeton Unviersity, Princeton, NJ
  - L.W. Cheng, University of Maryland – Baltimore County, Baltimore County, MD
  - Scott W. Corzine, Agilent Technologies, Inc., Santa Clara, CA
  - J. Coudevylle, University of Paris – Sud 11, Orsay, France
  - Frederic Demmerle, Technical University of Munich, Germany
  - Laurent Diehl, Harvard University, Cambridge, MA
  - T. Edamura, Hamamatsu Photonics, Hamamatsu City, Japan
  - Jonathan Fan, Harvard University, Cambridge, MA
  - Milan Fischer, ETH Zurich, Zurich, Switzerland
  - S. Furuta, Hamamatsu Photonics, Hamamatsu City, Japan
  - Markus Geiser, Harvard University, Cambridge, MA
  - V.-M. Gkortsas, Massachusetts Institute of Technology, Cambridge, MA
  - Ariel Gordon, Massachusetts Institute of Technology, Cambridge, MA
  - Anish K. Goyal, Massachusetts Institute of Technology Lincoln Laboratory, Lexington, MA

- P. Grant, Institute for Microstructural Sciences, National Research Council of Canada, Ottawa, Canada
- Christian Grasse, Technical University of Munich, Germany
- S. Haffouz, Institute for Microstructural Sciences, National Research Council of Canada, Ottawa, Canada
- T. Hosoda, State University of New York at Stony Brook, Stony Brook, NY
- Christian Jirauschek, Massachusetts Institute of Technology, Cambridge, MA
- Seungyong Jung, State University of New York at Stony Brook, Stony Brook, NY
- Jan Kansky, Massachusetts Institute of Technology Lincoln Laboratory, Lexington, MA
- Mikhail A. Kats, Harvard University, Cambridge, MA
- Suraj P. Khanna, University of Leeds, United Kingdom
- Simeon Katz, Technical University of Munich, Germany
- I. Kovacs, Technical University of Munich, Germany
- Lyubov Kuznetsova, Harvard University, Cambridge, MA
- Tae-Yoon Kwon, Max Planck Institute for the Physics of Complex Systems, Dresden, Germany
- Benjamin G. Lee, Harvard University, Cambridge, MA
- R. Lewicki, Rice University, Houston, TX
- X. Li, Harvard University, Cambridge, MA
- James MacArthur, Harvard University, Cambridge, MA
- Alpar Matyas, Technical University of Munich, Germany
- Ralf Meyer, Technical University of Munich, Germany
- Christian Pflügl, Harvard University, Cambridge, MA
- C.Y. Song, Institute for Microstructural Sciences, National Research Council of Canada, Ottawa, Canada
- Elodie Strupiechonski, University of Paris – Sud 11, Orsay, France
- Augustinas Vizbaras, Technical University of Munich, Germany
- Christine Y. Wang, Harvard University, Cambridge, MA
- Qi Jie Wang, Harvard University, Cambirdge, MA
- X. Wang, AdTech Optics, Inc., City of Industry, CA
- A. Wittmann, ETH Zurich, Zurich, Switzerland
- C. Yan, Harvard University, Cambridge, MA
- N. Yu, Harvard University, Cambridge, MA
- H.A. Zhang, Harvard University, Cambridge, MA
- Yang Zhao, The University of Texas at Austin, Austin, TX

List of Journal Papers Published in Rank and Percentage Contributions:

1. K. Vijayraghavan, M. Jang, A. Jiang, X. Wang, **M. Troccoli**, and **M.A. Belkin**, "Room-temperature terahertz sources with MOVPE grown quantum cascade lasers," under review (2013). **(MAB 95%; MT 5%)**
2. F. Lu, M. Jin, and **M.A. Belkin**, "Mid-infrared molecular force spectroscopy," under review (2013). **(MAB 100%)**

3. **S. Suchalkin, G. Belenky**, T. Hosoda, S. Jung, and **M.A. Belkin**, "Distributed Feedback Quantum Cascade Laser with optically tunable emission frequency," *Appl. Phys. Lett.*, accepted (2013). **(MAB 20%, SS 50%, GB 30%)**
4. K. Vijayraghavan, Y. Jiang, M. Jang, A. Jiang, K. Choutagunta, A. Vizbaras, F. Demmerle, G. Boehm, **M. C. Amann**, and **M. A. Belkin**, "Broadly tunable terahertz generation in mid-infrared quantum cascade lasers," *Nature Comm.* **4,** 2021-1 – 2021-7 (June 2013). **(MAB 90%, MCA 10%)**
5. **S. Suchalkin,** S. Jung, **R. Tober, M.A. Belkin**, and **G. Belenky**, "Optically tunable long wavelength infrared quantum cascade laser operated at room temperature," *Appl. Phys. Lett.* **102(1),** 011125-1 – 011125-4 (Jan. 2013). **(MAB 30%, SS 50%, RT 10%, GB 10%)**
6. M. Jang, **S. Suchalkin**, and **M.A. Belkin**, "Mid-infrared quantum cascade lasers with electrical control of the emission frequency," *IEEE J. of Quantum Electron.* **49(1),** 60-64 (Jan. 2013). **(MAB 90%, SS 10%)**
7. K. Vijayraghavan, R.W. Adams, A. Vizbaras, M. Jang, C. Grasse, G. Boehm, **M.C. Amann**, and **M.A. Belkin**, "Terahertz sources based on Čerenkov difference-frequency generation in quantum cascade lasers," *Appl. Phys. Lett.* **100(25),** 251104-1 – 251104-4 (June 2012). **(MAB 90%, MCA 10%)**
8. Y. Zhao, **M.A. Belkin**, and **A. Alu**, "Twisted optical metamaterials for planarized, ultrathin, broadband circular polarizers," *Nature Comm.* **3,** 870-1 – 870-7 (May 2012). **(MAB 10%, AA 90%)**
9. A. Matyas, R. Chashmahcharagh, I. Kovacs, **P. Lugli**, K. Vijayraghavan, **M.A. Belkin**, and **C. Jirauschek**, "Improved terahertz quantum cascade laser with variable height barriers," *J. Appl. Phys.* **111(10),** 103106-1 – 103106-6 (May 2012). **(MAB 40%, PL 10%, CJ 50%)**
10. A. Vizbaras, M. Anders, C. Grasse, S. Katz, G. Boehm, R. Meyer, **M.A. Belkin**, and **M.-C. Amann**, "Short-wavelength InP quantum cascade laser sources by quasi-phase-matched intracavity second-harmonic generation," *Phys. Status Solidi C* **9(2),** 298-301 (Feb. 2012). **(MAB 20%, MCA 80%)**
11. Y. Chassagneux, Q.J. Wang, S.P. Khanna, E. Strupiechonski, J. Coudevylle, **E.H. Linfield**, **A.G. Davies**, **F. Capasso**, **M.A. Belkin**, and **R. Colombelli**, "Limiting factors to the temperature performance of THz quantum cascade lasers based on the resonant-phonon depopulation scheme," *IEEE Trans. Terahertz Sci. Technol.* **2(1),** 83-92 (Jan. 2012). (Invited paper) **(MAB 30%, EHL 15%, AGD 5%, FC 10%, RC 40%)**
12. F. Lu and **M.A. Belkin**, "Infrared absorption nano-spectroscopy using sample photoexpansion induced by tunable quantum cascade lasers," *Optics Express* **19(21),** 19942-19947 (Sept. 2011). **(MAB 100%)**
13. J. Lee, F. Lu, and **M.A. Belkin**, "Broadly wavelength tunable bandpass filters based on long-range surface plasmon polaritons," *Opt. Lett.* **36(19),** 3744-3746 (Sept. 2011). **(MAB 100%)**
14. M. Jang, X. Wang, R.W. Adams, **M. Troccoli**, and **M.A. Belkin**, "Room-temperature 2.95μm quantum cascade laser sources based on intra-cavity frequency doubling," *Electron. Lett.* **47(11),** 667-668 (May 2011). **(MAB 95%, MT 5%)**
15. A. Vizbaras, M. Anders, S. Katz, C. Grasse, G. Boehm, R. Meyer, **M.A. Belkin**, and **M.-C. Amann**, "Room-temperature short-wavelength lambda=2.6μm quantum cascade laser sources by based on intracavity second-harmonic generation," *IEEE J. Quantum Electron.* **47(5),** 691-697 (May 2011). **(MAB 20%, MCA 80%)**
16. R.W. Adams, A. Vizbaras, M. Jang, C. Grasse, S. Katz, G. Boehm, **M.C. Amann, and M.A. Belkin**, "Terahertz sources based on intracavity frequency mixing in mid-infrared quantum

cascade lasers with passive nonlinear sections," *Appl. Phys. Lett.* **98(15),** 151114-1 – 151114-3 (Apr. 2011). **(MAB 90%, MCA 10%)**

17. M. Jang, R.W. Adams, J.X. Chen, W.O. Charles, **C. Gmachl**, L.W. Cheng, **F.-S. Choa**, and **M.A. Belkin**, "Room-temperature operation of 3.6μm $In_{0.53}Ga_{0.47}As/Al_{0.48}In_{0.52}As$ quantum cascade laser sources based on intracavity second harmonic generation," *Appl. Phys. Lett.* **97(14),** 141103-1 – 141103-3 (Oct. 2010). **(MAB 90%, CG 5%, FSC, 5%)**
18. R.W. Adams, K. Vijayraghavan, Q.J. Wang, J. Fan, **F. Capasso**, S.P. Khanna, **A.G. Davies**, **E.H. Linfield**, and **M.A. Belkin**, "$GaAs/Al_{0.15}Ga_{0.85}As$ terahertz quantum cascade lasers with double-phonon resonant depopulation operating up to 172 K," *Appl. Phys. Lett.* **97(13),** 131111-1 – 131111-3 (Oct. 2010). **(MAB 70%, EHL 15%, AGD 5%, FC 10%)**
19. V.-M. Gkortsas, C. Wang, L. Kuznetsova, L. Diehl, A. Gordon, C. Jirauschek, **M.A. Belkin**, **A. Belyanin**, **F. Capasso**, and **F.X. Kartner**, "Dynamics of actively mode-locked quantum cascade lasers," *Optics Express*, **18(13),** 13616-13630 (June 2010). **(MAB 5%, AB 25%, FC 30%, FXK 40%)**
20. A. Matyas, **M.A. Belkin**, **P. Lugli**, and **C. Jirauschek**, "Temperature performance analysis of terahertz quantum cascade lasers: vertical versus diagonal designs," *Appl. Phys. Lett.* **96(20),** 201110-1 – 201110-3 (May 2010). **(MAB 40%, PL 10%, CJ 50%)**
21. Q.J. Wang, C. Yan, L. Diehl, **M. Hentschel, J. Wiersig**, N. Yu, C. Pflugl, **M.A. Belkin**, T. Edamura, **M. Yamanishi, H. Kan**, and **F. Capasso**, "Deformed microcavity quantum cascade lasers with directional emission," *New J. Phys.* **11,** 125018-1 – 125018-17 (Dec. 2009). **(MAB 10%, MH 10%, JW 10%, MY 5%, HK 5%, FC 60%)**
22. N. Yu, M.A. Kats, C. Pflugl, M. Geiser, Q.J. Wang, **M.A. Belkin**, **F. Capasso**, M. Fischer, A. Wittmann, **J. Faist**, T. Edamura, S. Furuta, **M. Yamanishi,** and **H. Kan**, "Multi-beam multi-wavelength semiconductor lasers," *Appl. Phys. Lett.* **95(16),** 161108-1 – 161108-3 (Oct. 2009). **(MAB 5%, FC 85%, JF 5%, MY 2.5%, HK 2.5%)**
23. B.G. Lee, J. Kansky, A.K. Goyal, C. Pflugl, L. Diehl, **M.A. Belkin**, **A. Sanchez**, and **F. Capasso**, "Beam combining of quantum cascade laser arrays," *Optics Express* **17(18),** 16216-16224 (Aug. 2009). **(MAB 5%, AS 50%, FC 45%)**
24. C.Y. Wang, L. Kuznetsova, V.M. Gkortsas, L. Diehl, **F.X. Kärtner**, **M.A. Belkin**, **A. Belyanin**, X. Li, **D. Ham**, **H. Schneider,** P. Grant, C.Y. Song, S. Haffouz, **Z.R. Wasilewski**, **H.C. Liu**, and **F. Capasso**, "Mode-locked pulses from mid-infrared quantum cascade lasers," *Optics Express* **17(15),** 12929-12943 (July 2009). **(MAB 10%, FXK 10%, AB 10%, DH 5%, HS 5%, ZRW 5%, HCL 5%, FC 50%)**
25. B.G. Lee, H.A. Zhang, C. Pflügl, L. Diehl, **M.A. Belkin**, M. Fischer, A. Wittmann, **J. Faist**, and **F. Capasso**, "Broadband distributed-feedback quantum cascade laser array operating from 8.0 to 9.8μm," *IEEE Photon. Technol. Lett.* **21(13),** 914-916 (July 2009). **(MAB 10%, JF 10%, FC 80%)**
26. C. Yan, Q.J. Wang, L. Diehl, **M. Hentschel**, **J. Wiersig**, N. Yu, C. Pflügl, **F. Capasso**, **M.A. Belkin**, T. Edamura, **M. Yamanishi**, and **H. Kan**, "Directional emission and universal far-field behavior from semiconductor lasers with limaçon-shaped microcavity," *Appl. Phys. Lett.* **94(25),** 251101-1 – 251101-3 (June 2009). **(MAB 10%, MH 10%, JW 10%, FC 60%, MY 5%, HK 5%)**
27. **M. Hentschel**, T.-Y. Kwon, **M.A. Belkin**, R. Audet, and **F. Capasso**, "Angular emission characteristics of quantum cascade spiral microlasers," *Optics Express* **17(12),** 10335-10343 (June 2009). **(MAB 10%, MH 80%, FC 10%)**

28. **M.A. Belkin**, Q.J. Wang, C. Pfügl, **A. Belyanin**, S.P. Khanna, **E.H. Linfield**, and **F. Capasso**, "High temperature operation of terahertz quantum cascade laser sources," *IEEE J. Sel. Top. Quantum Electron.* **15(3),** 952-967 (May-June 2009). (Invited paper) **(MAB 60%, AB 10%, EHL 10%, FC 20%)**
29. B.G. Lee, **M.A. Belkin**, C. Pflügl, L. Diehl, H.A. Zhang, R.M. Audet, J. MacArthur, D.P. Bour, S.W. Corzine, **G.E. Höfler**, and **F. Capasso**, "DFB quantum cascade laser arrays," *IEEE J. Quantum Electron.* **45(5),** 554-565 (May 2009). **(MAB 30%, GEH 10%, FC 60%) = 80%**
30. **M. Troccoli**, L. Diehl, D.P. Bour, S.W. Corzine, N. Yu, C.Y. Wang, **M.A. Belkin**, **G. Höfler**, R. Lewicki, **G. Wysocki**, **F.K. Tittel**, and **F. Capasso**, "High-performance quantum cascade lasers grown by metal-organic vapor phase epitaxy and their applications to trace gas sensing," *IEEE J. of Lightwave Technology* **26(21),** 3534-3555 (Nov. 2008). **(MAB 10%, MT 30%, GH 5%, GW 10%, FKT 20%, FC 25%)**
31. C. Pfügl, **M.A. Belkin**, Q.J. Wang, M. Geiser, **A. Belyanin,** M. Fischer, A. Wittmann, **J. Faist,** and **F. Capasso**, "Surface-emitting terahertz quantum cascade laser source based on intracavity difference-frequency generation," *Appl. Phys. Lett.* **93(16),** 161110-1 – 161110-3 (Oct. 2008). **(MAB 25%, JF 10%, FC 65%)**

Works Forthcoming

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No works forthcoming.

No leaves without pay taken.

SUMMARY OF ACTIVITIES FOR
MIKHAIL BELKIN
Sept. 1, 2010 – August 31, 2011

A. Research:

1. Awards and Honors

2. Invited Addresses and Colloquia

1. M.A. Belkin, "Nanoscale imaging, optoelectronics, and plasmonics in mid-infrared," Schottky Seminar, Walter Schottky Institute, Technical University of Munich, Garching, Germany, July 2011. (Seminar)
2. M.A. Belkin, "Nanoscale imaging, optoelectronics, and plasmonics in mid-infrared," Photonics Seminar, Technical University of Vienna, Vienna, Austria, July 2011. (Seminar)
3. M.A. Belkin, "Nanoscale imaging, optoelectronics, and plasmonics in mid-infrared," Laser Seminar, ETH Zurich, Switzerland, July 2011. (Seminar)
4. M.A. Belkin, M. Jang, R.W. Adams, J. X. Chen, W. O. Charles, C. Gmachl, X. Wang, M. Troccoli, A. Vizbaras, M. Anders, S. Katz, C. Grasse, G. Boehm, R. Meyer, and M.C. Amann, L. W. Cheng, F.-S. Choa, "2.6-3.6 micron InGaAs/AlInAs quantum cascade laser sources based on intra-cavity second harmonic generation," 20th International Laser Physics Workshop, Sarajevo, Bosnia and Herzegovina, July 2011. (Invited talk)
5. A. Vizbaras, C. Grasse, R. W. Adams, M. A. Belkin, M. C. Amann "Quantum cascade lasers with integrated nonlinearity for difference-frequency (THz) and second harmonic (near infrared) generation," Villa Conference on Interactions Among Nanostructures (VCIAN), Las Vegas, NV, April, 2011. (Invited talk)
6. M.A. Belkin, M. Jang, R.W. Adams, J.X. Chen, W.O. Charles, C. Gmachl, L.W. Cheng, F.-S. Choa, X. Wang, M. Troccoli, A. Vizbaras, M. Anders, C. Grasse, and M.-C. Amann, "InGaAs/AlInAs quantum cascade laser sources based on intra-cavity second harmonic generation emitting in 2.6-3.6 micron range" SPIE Photonics West, San Francisco, CA, January 2011. (Invited talk)
7. M.A. Belkin and F. Lu, "Photoacoustic microscopy with quantum cascade lasers," International Quantum Cascade Lasers School and Workshop, Florence, Italy, September 2010. (Invited talk)

3. Publications

(a) Journals and books
Indicate published, accepted for publication, revised or submitted and under review.

1. J. Lee, F. Lu, and M.A. Belkin, "Broadly wavelength tunable bandpass filters based on long-range surface plasmon polaritons," *Opt. Lett.* **36,** 3744 (2011).
2. F. Lu, and M.A. Belkin, "Infrared absorption nano-spectroscopy using sample photoexpansion induced by tunable quantum cascade lasers," *Optics Express* **19,** 19942 (2011).
3. M. Jang, X. Wang, R.W. Adams, M. Troccoli, and M.A. Belkin, "Room-temeprature 2.95um quantum cascade laser sources based on intra-cavity frequency doubling," *Electron. Lett.* **47,** 667 (2011).
4. R.W. Adams, A. Vizbaras, M. Jang, C. Grasse, S. Katz, G. Boehm, M.C. Amann, and M.A. Belkin, "Terahertz Sources Based on Intracavity Frequency Mixing in Mid-Infrared Quantum Cascade Lasers with Passive Nonlinear Sections," *Appl. Phys. Lett.* **98,** 151114 (2011).
5. A. Vizbaras, M. Anders, S. Katz, C. Grasse, G. Boehm, R. Meyer, M.A. Belkin, and M.-C. Amann, "Room-temperature $\lambda \approx 2.7$ μm quantum cascade laser sources based on intracavity second-harmonic generation," *IEEE J. Quantum Electon.* **47,** 691 (2011).

6. M. Jang, R.W. Adams, J.X. Chen, W.O. Charles, C. Gmachl, L.W. Cheng, F.-S. Choa, and M.A. Belkin, "Room-temperature operation of 3.6μm $In_{0.53}Ga_{0.47}As/Al_{0.48}In_{0.52}As$ quantum cascade laser sources based on intra-cavity second harmonic generation," *Appl. Phys. Lett.* **97,** 141103 (2010).
7. R.W. Adams, K. Vijayraghavan, Q.J. Wang, J. Fan, F. Capasso, S.P. Khanna, A.G. Davies, E.H. Linfield, and M.A. Belkin, "$GaAs/Al_{0.15}Ga_{0.85}As$ terahertz quantum cascade lasers with double-phonon resonant depopulation operating up to 172 K," *Appl. Phys. Lett.* **97,** 131111 (2010).

(b) Refereed Conference Proceedings

1. M. Jang, X. Wang, M. Troccoli, and M.A. Belkin, "Room-temperature operation of λ≈2.95μm $In_{0.67}Ga_{0.33}As/Al_{0.57}In_{0.43}As$ quantum cascade laser source based on intra-cavity second harmonic generation," Proceedings of CLEO-QELS conference, Baltimore, MD (May 2011).
2. R.W. Adams, A. Vizbaras, C. Grasse, S. Katz, G. Boehm, M. Vijayraghavan, M. Jang, M.C. Amann, Y.H. Cho, A. Belyanin, and M.A. Belkin, "Terahertz Quantum Cascade Sources based on Intra-cavity Frequency Mixing in Passive Nonlinear Sections," Proceedings of CLEO-QELS conference, Baltimore, MD (May 2011).
3. F. Lu and M.A. Belkin, "Mid-infrared absorption microscopy with λ/100 spatial resolution using tunable quantum cascade lasers," Proceedings of CLEO-QELS conference, Baltimore, MD (May 2011).
4. A. Vizbaras, M. Anders, R. W. Adams, C. Grasse, S. Katz, G. Boehm, R. Meyer, M. A. Belkin, M. C. Amann "InP-based quantum cascade lasers with transversely integrated giant nonlinearity for wavelength generation in the 2.6 μm - 70 μm range by intracavity nonlinear frequency mixing," Proc. of the 40th Freiburg Infrared Colloquium, Freibug, Germany, (February, 2011).
5. M.A. Belkin, M. Jang, R.W. Adams, J.X. Chen, W.O. Charles, C. Gmachl, L.W. Cheng, F.-S. Choa, X. Wang, M. Troccoli, A. Vizbaras, M. Anders, C. Grasse, and M.-C. Amann, "InGaAs/AlInAs quantum cascade laser sources based on intra-cavity second harmonic generation emitting in 2.6-3.6 micron range" *Proc. SPIE* **7953,** 795315 (2011). (Invited paper)
6. Y.H. Cho, M.A. Belkin, A. Belyanin, "Upper limits on terahertz difference frequency generation power in quantum well heterostructures," *Proc. SPIE,* **7953,** 79530U (2011).
7. A. Vizbaras, S. Katz, M. Anders, C. Grasse, G. Boehm, R. Meyer, M.A. Belkin, M.-C. Amann, "Injectorless quantum cascade lasers for room-temperature short-wavelength emission by efficient second-harmonic generation," 23rd Annual Meeting of the IEEE Photonics Society, pp. 367-368 (2010).

(c) Conference Presentations Without Proceedings of Full Papers (excluding invited talks listed in part 2)

1. C. Grasse, A. Vizbaras, G. Boehm, R. Meyer, M. Belkin, M. C. Amann "Short-wavelength injectorless quantum cascade laser based on second-harmonic generation," International Nano-Optoelectronics Workshop (iNow), St. Petersburg and Würzburg, Russia & Germany (July-August, 2011). **"Best Poster Award 2011" (Third Place)**
2. A. Vizbaras, M. Anders, C. Grasse, S. Katz, G. Boehm, R. Meyer, M. A. Belkin, M. C. Amann "Short-wavelength InP quantum cascade laser sources by quasi-phase-matched intracavity second-harmonic generation," International Symposium on Compound Semiconductors (ISCS-2011), Berlin, Germany, (May, 2011).
3. F. Lu and M.A. Belkin, "Cantilever resonance enhanced photoacoustic spectroscopic microscopy with mid-infrared quantum cascade lasers," Materials Research Society Fall Meeting, Boston, MA (November-December, 2010).

3. Student Advising

(a) Completed PhD Theses
Names of students and program (e.g. ECE, CS, Physics, etc.)

None yet

(b) Current Graduate Advisees

PhD: Mr. Robert Adams, Mr. Min Jang, Mr. Feng Lu, Mr. Karun Vijayraghavan, and Mr. Jongwon Lee.

Number of graduate students supported by grants, 2009-10	Number of graduate students supported by grants, 2011-12 (*anticipated*)	Number of Ph.D. advisees supported as T.A., Fellow, etc., 2010-11	Number of Ph.D. advisees supported as T.A., Fellow, etc., 2011-12 (*anticipated*)
5	5-6	0	0

4. Current Research Projects and Grants

Title, agency, PI, role, amount, duration

1. Welch foundation grant No. F-1705 "Mid-infrared photoacoustic spectroscopy with nanometer resolution using quantum cascade lasers," period 6/1/2009-5/31/2012, funding amount $150,000, OSP number 2009001156.
2. NSF grant No. ECCS-0925217 "COLLABORATIVE RESEARCH: Room-temperature terahertz semiconductor Raman lasers," period 9/1/2009-8/31/2012, PI Mikhail Belkin UT Austin, co-PI Alexey Belyanin, TAMU; funding amount $306,887 (my share); OSP number 200900296.
3. AFOSR YIP grant No. FA9550-10-1-0076 "Tunable Quantum Electronic Metamaterials for Mid-Infrared," period of performance 4/1/2010-3/31/2013, funding amount $359,178; OSP number 200902280.
4. Texas Higher Education Coordinating Board grant No. 01892 "Room-temperature electrically-pumped semiconductor sources of THz radiation," period 7/1/2010-8/31/2012, PI Mikhail Belkin UT Austin, co-PI Alexey Belyanin, TAMU; funding amount $132,381 (my share). OSP number 200902628.
5. NSF grant No. ECCS-1028473, "COLLABORATIVE: Ultra-fast tunable quantum cascade lasers" period 9/15/2010-9/1/2012, PI Gregory Belenky SUNY Stony Brook, co-PI Mikhail Belkin UT Austin, funding amount $142,095 (my share); OSP number 201000419.

We are also pursuing a number of small-scale 'exploratory' projects on widely-tunable bandpass filters, FTIR-based optical microscopy, short-wavelength mid-IR sources based on SHG, etc.

5. Proposal Submissions

Pending proposals:

1. AFOSR MURI "Spectrally Selective Low Loss Quantum Metamaterials"; suggested period of performance 6/1/2012-5/31/2015 (base period) + 6/1/2015-5/31/2017 (option period), requested amount $390,000 (PI share, base period) + $260,000 (PI share, option period).

2. DOE STTR Phase I grant "Resonance-Enhanced Infrared Nanospectroscopy (REINS) based on Atomic Force Microscopy and Quantum Cascade Lasers," with Anasys Instruments, Inc.; suggested period of performance 2/1/2012-10/31/2012, requested amount $90,000 (PI share).
3. DOE STTR Phase I grant "Monolithic Chip-Integrated Mid-Infrared Absorption Spectrometer for Highly Sensitive Carbon Dioxide Detection on Ballonsonde Platform," with Omega Optics; suggested period of performance 2/1/2012-10/31/2012, requested amount $50,000 (PI share).
4. Texas Higher Education Coordination Board "Short wavelength quantum Cascade Lasers with Internal Frequency Doubling"; suggested period of performance 5/1/2012-8/31/-2014, requested amount $80,000 (single PI proposal).
5. NASA SBIR Phase I grant "Monolithic Tunable Laser Based Photonic Crystal Sensor for On-Chip Optical Absorption Spectroscopy," with Omega Optics; suggested period of performance 1/1/2012-6/30/2012, requested amount $41,660 (PI share).
6. NSF CAREER grant "Terahertz semiconductor laser sources for operation above cryogenic temperatures"; suggested period of performance 5/1/2012-4/31/2017, requested amount $480,238 (single PI proposal).
7. DARPA BAA grant "Photonic Crystal Open Sensor Platform for Chip-Integrated High Throughput Low-Cost Sensing and Spectroscopy"; suggested period of performance 1/1/2012-12/31/2012, requested amount $150,000 (PI share).

B. Teaching

6. Special Projects, Lab and Course Developments, etc.

Developed (Fall 2009) and improved (Fall 2010) 'Nonlinear Optics' course (EE 383V) for graduate students

C. Service Activities

7. University Service

Member of the 'Transition committee' at the ECE department, SSE area coordinator

8. Technical Society Service

Co-chair, The 12th International Conference on Intersubband Transitions in Quantum Wells (September 2013).

Member of the program committee for the 11th International Conference on Intersubband Transitions in Quantum Wells (North Sardinia, Italy, September 2011).

Member of the organization committee for the 35th International Conference on Infrared, Millimeter and Terahertz Waves (Houston, TX, October 2011).

Session chair: International Quantum Cascade Lasers School and Workshop, Florence, Italy (September 2010), CLEO conference, Baltimore, MD (May 2011).

C. Other Items of Interest

Provisional patents (Sept. 1, 2010 – Aug. 31, 2011)

M.A. Belkin, "Tunable Optical Filters Based on Long-Range Surface Plasmon-Polariton Waveguides," USPTO provisional application number 61/466,330, filed in March 2011.

Utility patents (Sept. 1, 2010 – Aug. 31, 2011)

M.A. Belkin and W. Masselink, "Terahertz quantum cascade lasers," USPTO application number 13/148.459, filed on Aug. 8, 2011.

M.A. Belkin, "Quantum cascade lasers (QCLs) configured to emit light having a wavelength in the 2.5-3.8 micrometer band," USPTO application number 12/791,587, filed on June 1, 2010, published on Dec. 9, 2010.

Patents granted (Sept. 1, 2010 – Aug. 31, 2011)

M.A. Belkin, F. Capasso, A. Belyanin, "Methods and apparatus for generating terahertz radiation" USPTO number 7974325, issued July 5, 2011.

M.A. Belkin, B.G. Lee, R.M. Audet, J.B. MacArthur, L. Diehl, C. Pflugl, F. Capasso, "Broadly tunable single-mode quantum cascade laser sources and sensors" USPTO number 7826509, issued Nov. 2, 2011.

E. Plans for the Coming Year

The main objective for the coming year is to produce high-quality and high-impact-factor research results in the fields of mid-infrared and THz quantum cascade lasers, microscopy, plasmonics, and metamaterials. We plan to try publishing two papers in high-quality journals such as Nature Photonics or Science.

Securing additional funding for group expansion is another goal. We hope to be able to secure enough funding to finish building another lab space and to expand the group by 1-2 more people next year.

SUMMARY OF ACTIVITIES FOR
MIKHAIL BELKIN
Sept. 1, 2011 – August 31, 2012

A. Research:

1. Awards and Honors

- NSF CAREER award (2012)
- DARPA Young Faculty Award (2012)
- The Norman Hackerman Advanced Research Program Award for Early Career Investigators (2012)
- IEEE Senior Member (2012)

2. Invited Addresses and Colloquia (given by me or students from my group)

1. M.A. Belkin, "THz generation and nanoscale chemical imaging with quantum cascade lasers," Institute of Fundamental Electronics, University of Paris – South, Orsay, France, September 12, 2012 (Seminar)
2. M.A. Belkin, "Nanoscale chemical imaging with quantum cascade lasers," Walter Schottky Institute, Technical University of Munich, Garching, Germany, September 6, 2012 (Seminar)
3. M.A. Belkin, "THz generation and nanoscale chemical imaging with quantum cascade lasers," Department of Electrical Engineering, University of California – Los Angeles, Los Angeles, CA, August 14, 2012 (Seminar)
4. M.A. Belkin, "THz generation and nanoscale chemical imaging with quantum cascade lasers," The International Laser Center, Moscow State University, Moscow, Russia, June 8, 2012 (Seminar)
5. M.A. Belkin, "Terahertz quantum cascade lasers: Progress towards room-temperature operation," Defense Science Research Council (DSRC) workshop on "Solid state devices with vacuum tube-like electron dynamics for high-power terahertz generation" Arlington, VA, February 2, 2012 (Invited talk)
6. M.A. Belkin, "Nanoscale chemical imaging and THz generation using quantum cascade lasers," Air Force Research Laboratory, Brooks City-Base, TX, October 2011. (Seminar)
7. M.A. Belkin, "Nanoscale imaging and plasmonic devices in infrared" Princeton Institute for the Science and Technology of Materials (PRISM) seminar, Princeton University, Princeton, NJ, October 2011. (Seminar)
8. R.W. Adams, A. Vizbaras, C. Grasse, S. Katz, G. Boehm, K. Vijayraghavan, M. Jang, Y.H. Cho, A. Belyanin, M.-C. Amann, M.A. Belkin, "THz Quantum Cascade Sources based on Intra-cavity Frequency Mixing in Passive Nonlinear Sections," 36th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), Houston, TX, October 2011. (Invited talk, given by a student in my group) **2nd place in best student paper competition**
9. F. Lu and M.A. Belkin, "Quantum-Cascade Laser-Based Nanoscale Photoexpansion Micro-Spectroscopy in Mid-Infrared and Terahertz," 36th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), Houston, TX, October 2011. (Invited talk, given by a student in my group)
10. M.A. Belkin and Feng Lu, "Infrared absorption nano-spectroscopy with quantum cascade lasers," Federation of Analytical Chemistry and Spectroscopy Societies (FACSS) conference, Reno, NV, October 2011. (Invited talk)

Invited talks listed below are given by our collaborators, but they list our group as co-authors:

11. A. Vizbaras, R. W. Adams, C. Grasse, M. Jang, R. Meyer, M. A. Belkin, and M.-C. Amann, "Nonlinear GaInAs/AlInAs/InP quantum cascade laser sources for wavelength generation in the 2.7-70 μm wavelength range," SPIE Photonics West, San Francisco, CA, January 2012. (Invited talk)
12. A. Vizbaras, K. Vijayraghavan, R.W. Adams, G. Boehm, M.A. Belkin, and M.C. Amann, "Terahertz quantum cascade laser sources based on difference-frequency generation: from passive nonlinearity to leaky THz waveguide device," SPIE Optics and Photonics, San Diego, CA, August 2012. (Invited talk)

3. Publications

(a) Journals and books

Indicate published, accepted for publication, revised or submitted and under review.

1. S. Suchalkin, S. Jung, R.Tober, M.A. Belkin, and G. Belenky, "Optically tunable long wavelength infrared quantum cascade laser operated at room temperature," under review (2012).
2. M. Jang, S. Suchalkin, and M.A. Belkin, "Mid-infrared quantum cascade lasers with electrical control of the emission frequency," under review (2012).
3. K. Vijayraghavan, R.W. Adams, A. Vizbaras, M. Jang, C. Grasse, G. Boehm, M. C. Amann, and M.A. Belkin "Terahertz Sources Based on Čerenkov Difference-Frequency Generation in Quantum Cascade Lasers," *Appl. Phys. Lett.* **100,** 251104 (2012).
4. Y. Zhao, M.A. Belkin, and A. Alu, "Twisted optical metamaterials for planarized, ultrathin, broadband circular polarizers," *Nature Comm.* **3,** 870 (2012).
5. A. Matyas, R. Chashmahcharagh, I. Kovacs, P. Lugli, K. Vijayraghavan, M.A. Belkin, and C. Jirauschek, "Improving terahertz quantum cascade lasers by using barriers with various heights," *J. Appl. Phys.* **111,** 103106 (2012).
6. A. Vizbaras, M. Anders, C. Grasse, S. Katz, G. Boehm, R. Meyer, M.A. Belkin, and M.-C. Amann, "Short-wavelength InP quantum cascade laser sources by quasi-phase-matched intracavity second-harmonic generation," *Phys. Status Solidi C* **9,** 298 (2012).
7. Y. Chassagneux, Q.J. Wang, S.P. Khanna, E. Strupiechonski, J.-R. Coudevylle, E.H. Linfield, A.G. Davies, F. Capasso, M.A. Belkin, and R. Colombelli, "Limiting factors to the temperature performance of THz quantum cascade lasers based on the resonant-phonon depopulation scheme," *IEEE Trans. Terahertz Sci. Technol.* **2,** 83 (2012). **(invited paper)**
8. J. Lee, F. Lu, and M.A. Belkin, "Broadly wavelength tunable bandpass filters based on long-range surface plasmon polaritons," *Opt. Lett.* **36,** 3744 (2011).
9. F. Lu, and M.A. Belkin, "Infrared absorption nano-spectroscopy using sample photoexpansion induced by tunable quantum cascade lasers," *Optics Express* **19,** 19942 (2011).

(b) Refereed Conference Proceedings

1. A. Vizbaras, K. Vijayraghavan, R.W. Adams, G. Boehm, M.A. Belkin, and M.C. Amann, "Terahertz quantum cascade laser sources based on difference-frequency generation: from passive nonlinearity to leaky THz waveguide device," *Proc. SPIE* **8496,** 8496-06 (2012). **(invited paper)**
2. K. Vijayraghavan, R.W. Adams, A. Vizbaras, M. Jang, C. Grasse, G. Boehm, M.C. Amann, and M.A. Belkin, "Terahertz quantum cascade laser sources based on Cerenkov differencefrequency generation," *Proc. SPIE* **8496,** 8496-07 (2012).

3. F. Lu and M.A. Belkin, "Plasmonic-enhanced infrared photoexpansion nano-spectroscopy using tunable quantum cascade lasers," *Proc. SPIE* **8466,** 8466-17 (2012).
4. J. Lee, F. Lu, and M.A. Belkin, "Widely-tunable optical bandpass filter based on long-range surface plasmon polaritons," *Proc. SPIE* **8457,** 8457-89 (2012).
5. F. Lu and M. Belkin, "Tip-enhanced photoexpansion nano-spectroscopy using tunable quantum cascade lasers," in *CLEO:2012 - Laser Applications to Photonic Applications*, OSA Technical Digest (CD) (Optical Society of America, 2012), paper QF3D4.
6. K. Vijayraghavan, R. W. Adams, A. Vizbaras, C. Grasse, S. Katz, G. Boehm, M. C. Amann, and M. Belkin, "Terahertz quantum cascade laser sources based on Cherenkov intra-cavity difference-frequency generation," in *CLEO:2012 - Laser Applications to Photonic Applications*, OSA Technical Digest (CD) (Optical Society of America, 2012), paper CTh4N2**.**
7. S. Suchalkin, M. Jang, S. Jung, R. Tober, M.A. Belkin, and G. Belenky, "Fast electrical wavelength modulation of mid-infrared quantum cascade lasers," in *CLEO:2012 - Laser Applications to Photonic Applications*, OSA Technical Digest (CD) (Optical Society of America, 2012), paper CTh3N5**.**
8. J. Lee, F. Lu, and M. Belkin, "Widely wavelength tunable optical filters using characteristics of long-range surface plasmon polaritons," in *CLEO:2012 - Laser Applications to Photonic Applications*, OSA Technical Digest (CD) (Optical Society of America, 2012), paper QM2K4.
9. A. Vizbaras, R.W. Adams, C. Grasse, M. Jang, R. Meyer, M.A. Belkin, and M.C. Amann, "Nonlinear GaInAs/AlInAs/InP quantum cascade laser sources for wavelength generation in the 2.7-70μm wavelength range," *Proc. SPIE* **8268,** 82680L (2012). **(invited paper)**
10. J. Lee, F. Lu, and M.A. Belkin, "Widely tunable waveguide filters based on long-range surface plasmon polaritons," *Proceedings of 2011 IEEE Photonics Conference*, pp. 17-18 (2011).
11. R. Adams, K. Vijayraghavan, Q.J. Wang, J. Fan, F. Capasso, S. Khanna, L. Li, A.G. Davies, E. Linfield, and M. Belkin, "GaAs/$Al_{0.15}Ga_{0.85}As$ terahertz quantum cascade lasers with double phonon resonant depopulation operating up to 172 K," in Proc. International Conference on Infrared, Millimeter, and Terahertz Waves, Houston, TX, Oct 2-7, 2011, pp. 541-542.
12. R. Adams, A. Vizbaras, C. Grasse, S. Katz, G. Boehm, K. Vijayraghavan, M. Jang, Y.H. Cho, A. Belyanin, M. Amann, and M. Belkin "THz quantum cascade sources based on intra-cavity frequency mixing in passive nonlinear sections," in Proc. International Conference on Infrared, Millimeter, and Terahertz Waves, Houston, TX, Oct 2-7, 2011, p. 583-585. **(invited paper)**
13. K. Vijayraghavan, R. Adams, Y.H. Cho, A. Belyanin, S. Khanna, L. Li, A.G. Davies, E. Linfield, M. Belkin "Intersubband Raman laser for operation at terahertz frequencies," in Proc. International Conference on Infrared, Millimeter, and Terahertz Waves, Houston, TX, Oct 2-7, 2011, pp. 590-591.
14. F. Lu and M. Belkin, "Quantum-cascade laser-based nanoscale photoexpansion microspectroscopy in mid-infrared and terahertz," in Proc. International Conference on Infrared, Millimeter, and Terahertz Waves, Houston, TX, Oct 2-7, 2011, pp. 990-992. **(invited paper)**

(c) Conference Presentations Without Proceedings of Full Papers

1. M.A. Belkin, F. Lu, M. Salih, P. Dean, S.P. Khanna, L. Li, A.G. Davies, E. H. Linfield "Mid- and far-infrared absorption micro-spectroscopy with better than 50 nm spatial resolution using quantum cascade lasers," 11th International Conference on Intersubband Transitions in Quantum Wells, North Sardinia, Italy, (September 2011).
2. A. Vizbaras, R. W. Adams, M. Jang, M. A. Belkin, C. Grasse, G. Boehm, Y. H. Cho, A. Belyanin, M. C. Amann "Extending the spectral range of GaInAs/AlInAs/InP quantum cascade lasers by intracavity nonlinear frequency mixing," 11th International Conference on Intersubband Transitions in Quantum Wells, North Sardinia, Italy, (September 2011).

3. Student Advising

(a) Completed PhD Theses
Names of students and program (e.g. ECE, CS, Physics, etc.)

None yet

(b) Current Graduate Advisees

PhD: **1.** Mr. Min Jang,
2. Mr. Feng Lu,
3. Mr. Karun Vijayraghavan,
4. Mr. Jongwon Lee,
5. Mr. Aiting Jiang,

Two additional PhD students start in Fall 2012:
6. Mr. Jacob VanWagoner
7. Ms. Mingzhou Jin

MS: **1.**Ms. Yifan Jiang

Number of graduate students supported by grants, 2011-12	Number of graduate students supported by grants, 2012-13 (*anticipated*)	Number of Ph.D. advisees supported as T.A., Fellow, etc., 2011-12	Number of Ph.D. advisees supported as T.A., Fellow, etc., 2012-13 (*anticipated*)
6	7-8	1	1

(c) Undergraduate students

I supervised the research of a sophomore student Mr. Karthik Choutagunta in my laboratory in Fall and Spring 2012. Karthik focused on the development external cavity laser setup to create widely-tunable quantum cascade lasers. He has received Unrestricted Endowed Presidential Scholarship from the University of Texas in May 2012 based, in part, on his superb performance in my laboratory and my recommendation letter.

I served as a mentor for the Senior Design Project (EE362D) team in Spring and Summer 2012. The project title "Residential power factor correction". The team included students James Lundberg, Michael Marquez, and Trevor Latson.

I also hosted a summer undergraduate student in my group within the NSF National Nanotechnology Infrastructure Network (NNIN) Research Experience for Undergraduate (REU) program. A junior student Alexander Buck from Rensselaer Polytechnic Institute worked in my group from June 2012 to August 2012 on developing antireflection coatings for our THz quantum cascade laser sources.

4. Current Research Projects and Grants

Title, agency, PI, role, amount, duration

1. **$324,987** (my share) NSF grant No. ECCS-0925217 "COLLABORATIVE RESEARCH: Room-temperature terahertz semiconductor Raman lasers." Period 9/1/2009-8/31/2013, PI Mikhail Belkin UT Austin, co-PI Alexey Belyanin, TAMU. OSP number 200900296. The amount includes $18,100 supplement deposited on 5/23/2012.
2. **$359,178** AFOSR YIP grant No. FA9550-10-1-0076 "Tunable Quantum Electronic Metamaterials for Mid-Infrared." Single PI grant, period of performance 4/1/2010-3/31/2013, OSP number 200902280.
3. **$132,381** (my share) Texas Higher Education Coordinating Board grant No. 01892 "Room-temperature electrically-pumped semiconductor sources of THz radiation." Period 7/1/2010-8/31/2013, PI Mikhail Belkin UT Austin, co-PI Alexey Belyanin, TAMU. OSP number 200902628.
4. **$224,759** (my share) NSF grant No. ECCS-1028473, "COLLABORATIVE: Ultra-fast tunable quantum cascade lasers." Period 9/15/2010-9/1/2013, PI Gregory Belenky SUNY Stony Brook, co-PI Mikhail Belkin UT Austin. OSP number 201000419.
5. **$400,000** NSF CAREER grant No. ECCS-1150449, "CAREER: Terahertz semiconductor laser sources for operation above cryogenic temperatures." Single PI grant, period 5/1/2012-4/30/2017, OSP number 201101774.
6. **$90,000** (my share) DOE STTR Phase I, "Resonance-Enhanced Infrared Nanospectroscopy (REINS) based on Atomic Force Microscopy and Quantum Cascade Lasers" with Anasys Instruments. Period 2/1/2012-10/31/2012, OSP number 201102601.
7. **$120,000** Welch Foundation grant, "Plasmonic-enhanced nanoscale mid-infrared microscopy with monolayer sensitivity." Single PI grant, period 6/1/2012-5/31/2014, funding amount, OSP number 201200307.
8. **$80,000** Texas Higher Education Coordinating Board grant "Short-wavelength quantum cascade lasers with internal frequency doubling." Single PI grant, period 7/1/2012-8/31/2014, OSP number 201103624
9. **$150,000** subcontract from Omega Optics for Army Phase II SBIR project "Monolithic Photonic Crystal On-Chip Spectrometer for Laser Absorption Spectroscopy." Period 08/27/2012-05/02/2014, OSP number 201101753
10. **$150,000** DARPA Young Faculty Award grant "Room-Temperature High-Power Terahertz Semiconductor Laser Sources." Single PI grant, period 08/13/2012-08/12/2014, OSP number 201200103.

Total: $**2,031,305** (my share)

We are also pursuing a number of small-scale 'exploratory' projects on widely-tunable bandpass filters based on long-range surface plasmon-polaritons, sub-wavelength resolution mid-infrared microscopy with Fourier-transform infrared spectrometers, short-wavelength mid-IR sources based on intracavity second-harmonic generation, widely-tunable terahertz sources, nonlinear metasurfaces, etc.

5. Proposal Submissions

Pending proposals:

1. DOE Early Career Award pre-proposal "Ultra-sensitive nanoscale absorption spectroscopy in mid- and far-infrared," suggested period of performance 6/1/2013-5/31/2018, requested amount $750,000.
2. Semiconductor Research Corporation pre-proposal "Mid-infrared absorption nano-spectroscopy with monolayer sensitivity," suggested period of performance 3/1/2013-2/31/2016, requested amount $300,000.

B. Teaching

6. Special Projects, Lab and Course Developments, etc.

Developed (Fall 2009) and improved (Fall 2010, Fall 2011) 'Nonlinear Optics' course (EE 383V) for graduate students

C. Service Activities

7. University Service

Member of the 'Transition committee' at the ECE department

SSE area coordinator

8. Technical Society Service

Co-chair for the 12th International Conference on Intersubband Transitions in Quantum Wells (September 2013).

NSF ECCS panel reviewer (Jan 2012), proposal reviewer for the The French National Research Agency (ANR) (Feb 2012)

IEEE Photonics Society Central Texas Chapter Chair.

Reviewed papers for Nature Photonics, Nature Communications, IEEE Journal of Quantum Electronics, Applied Physics Letters, Optics Express, and other journals.

Session chair: CLEO conference, Baltimore, MD (May 2012), 11th International Conference on Intersubband Transitions in Quantum Wells, North Sardinia, Italy (September 2011).

D. Other Items of Interest

E. Plans for the Coming Year

The main objective for the coming year is to produce high-quality and high-impact-factor research results in the fields of mid-infrared and THz quantum cascade lasers, microscopy, plasmonics, and metamaterials. In particular, we aim to produce the first room-temperature semiconductor laser source of terahertz radiation (1-5 THz) with milliwatt-level power output within the next two years. Currently we demonstrated devices with ~30μW THz

power output at room temperature. We will make an effort to publish our best results in the best journal in the field (Nature-family journals, Science).

Securing additional funding for group expansion is another goal. We hope to secure enough funding to finish building another lab space and to expand the group by 1-2 more people next year.

SUMMARY OF ACTIVITIES FOR
MIKHAIL BELKIN
September 1, 2012 – August 31, 2013

A. Research:

1. Awards and Honors

2. Invited Addresses and Colloquia (given by me)

1. M.A. Belkin, "High performance broadly-tunable terahertz quantum cascade laser sources based on intra-cavity frequency mixing," The 21st International Symposium "Nanostructures: physics and technology," Saint Petersburg, Russia, June 2013. (**Invited talk**)
2. M. A. Belkin, K. Vijayraghavan, Y. Jiang, A. Jiang, F. Demmerle, G. Boehm, and M. Amann, "Room-temperature quantum cascade laser sources of terahertz radiation," CLEO-QELS, San Jose, CA, June 2013. (**Invited talk**)
3. M.A. Belkin, "Nanoscale mid-infrared vibrational spectroscopy with monolayer sensitivity," 96th Canadian Chemistry Conference, Quebec City, Canada, May 30, 2013. (**Invited talk**)
4. M.A. Belkin, "Broadly-tunable room-temperature THz quantum cascade laser sources," Electrical Engineering Seminar, University of Texas at Dallas, Richardson, TX, May 16, 2013. (**Seminar**)
5. M.A. Belkin, "Broadly-tunable room-temperature THz quantum cascade laser sources," Atomic, Molecular, and Optical Physics Seminar, Texas A&M University, College Station, TX, April 26, 2013. (**Seminar**)
6. M.A. Belkin, "Nanoscale infrared spectroscopy by detecting molecular forces," Electrical and Computer Engineering Seminar, University of Houston, Houston, TX, April 19, 2013. (**Seminar**)
7. M.A. Belkin, "Room-temperature electrically-pumped THz semiconductor sources," US-UK Workshop in Mid-IR to THz Technology and Applications, Edinburgh, UK, February 19, 2013. (**Invited talk**)
8. M.A. Belkin, K. Vijayraghavan, A. Vizbaras, A. Jiang, F. Demmerle, G. Boehm, R. Meyer, M.-C. Amann, A. Matyas, R. Chashmahcharagh, P. Lugli, C. Jirauschek, and Z.R. Wasilewski, "THz quantum cascade lasers for operation above cryogenic temperatures," SPIE Photonics West, San Francisco, CA, February 6, 2013. (**Invited talk**).
9. M.A. Belkin, F. Lu, M. Jin, M. Salih, P. Dean, S.P. Khanna, L.H. Li, G. Davies, and E.H. Linfield, "Terahertz and mid-infrared photoexpansion nanospectroscopy," SPIE Photonics West, San Francisco, CA, February 6, 2013. (**Invited talk**)
10. M. Belkin, "Infrared vibrational nanospectroscopy by detecting molecular forces," Texas A&M University Institute for Quantum Science and Engineering Workshop, College Station, TX, January 16, 2013. (**Invited talk**)
11. M. Belkin, K. Vijayraghavan, F. Demmerle, M. Jang, A. Jiang, C. Grasse, and M.-C. Amann, "Room-temperature THz quantum cascade laser sources," Photonics Global Conference, Singapore, December 15, 2012. (**Invited talk**)
12. M.A. Belkin, "Nanoscale spectroscopy and plasmonics in infrared," Electrical Engineering Seminar, Nanyang Technological University, Singapore, December 12, 2012. (**Seminar**)
13. M.A. Belkin, "Room temperature terahertz quantum cascade laser sources," Physics Department Seminar, Fudan University, Shanghai, China, December 10, 2012. (**Seminar**)
14. M.A. Belkin, "Room-temperature THz quantum cascade laser sources," Electrical Engineering Department Seminar, University of Wisconsin at Madison, Madison, WI, November 19, 2012. (**Seminar**)
15. M.A. Belkin, "THz generation and nanoscale chemical imaging with quantum cascade lasers," Optical, Electronic, and Quantum Systems Seminar, University of Colorado at Boulder, Boulder, CO, October 12, 2012. (**Seminar**)
16. M. Belkin and F. Lu, "Tip-enhanced mid-infrared and terahertz photoexpansion nanospectroscopy," SciX conference, Kansas City, MO, October 1, 2012. (**Invited talk**)

17. M.A. Belkin, "THz generation and nanoscale chemical imaging with quantum cascade lasers," Institute of Fundamental Electronics, University of Paris – South, Orsay, France, September 12, 2012. **(Seminar)**
18. M.A. Belkin, "Nanoscale chemical imaging with quantum cascade lasers," Walter Schottky Institute, Technical University of Munich, Garching, Germany, September 6, 2012. **(Seminar)**

3. Publications

(a) Journals and books

Indicate published, accepted for publication, revised or submitted and under review.

1. K. Vijayraghavan, M. Jang, A. Jiang, X. Wang, M. Troccoli, and M.A. Belkin, "Room-temperature terahertz sources with MOVPE grown quantum cascade lasers," under review (2013).
2. F. Lu, M. Jin, and M.A. Belkin, "Mid-infrared molecular force spectroscopy," under review (2013).
3. S. Suchalkin, G. Belenky, T. Hosoda, S. Jung, and M.A. Belkin, "Distributed Feedback Quantum Cascade Laser with optically tunable emission frequency," *Appl. Phys. Lett.* **103(4),** 041120-1 – 03112-3 (July 2013). http://dx.doi.org/10.1063/1.4816592
4. K. Vijayraghavan, Y. Jiang, M. Jang, A. Jiang, K. Choutagunta, A. Vizbaras, F. Demmerle, G. Boehm, M. C. Amann, and M. A. Belkin, "Broadly tunable terahertz generation in mid-infrared quantum cascade lasers," *Nature Comm.* **4,** 2021-1 – 2021-7 (June 2013). http://dx.doi.org/10.1038/ncomms3021
5. S. Suchalkin, S. Jung, R. Tober, M.A. Belkin, and G. Belenky, "Optically tunable long wavelength infrared quantum cascade laser operated at room temperature," *Appl. Phys. Lett.* **102(1),** 011125-1 – 011125-4 (Jan. 2013). http://dx.doi.org/10.1063/1.4774267
6. M. Jang, S. Suchalkin, and M.A. Belkin, "Mid-infrared quantum cascade lasers with electrical control of the emission frequency," *IEEE J. of Quantum Electron.* **49(1),** 60-64 (Jan. 2013). http://dx.doi.org/10.1109/JQE.2012.2227954

(b) Refereed Conference Proceedings

1. M.A. Belkin, K. Vijayraghavan, Y. Jiang, A. Jiang, F. Demmerle, G. Boehm, and M. Amann, "Room-temperature Quantum Cascade Laser Sources of Terahertz Radiation," in CLEO: 2013, OSA Technical Digest (online) (Optical Society of America, 2013), paper JTu1J.1, San Jose, CA (June 2013). **(Invited paper)** http://dx.doi.org/10.1364/CLEO_SI.2013.JTu1J.1
2. K. Vijayraghavan, M. Jang, A. Jiang, X. Wang, M. Troccoli, and M.A. Belkin, "Terahertz difference-frequency generation in quantum cascade lasers with high conversion efficiency," in CLEO: 2013, OSA Technical Digest (online) (Optical Society of America, 2013), paper JTu1J.5, San Jose, CA (June 2013). http://dx.doi.org/10.1364/CLEO_SI.2013.JTu1J.5
3. A. Jiang, K. Vijayraghavan, A. Matyas, C. Jirauschek, Z. Wasilewski, and M.A. Belkin, "Terahertz Quantum Cascade Laser Performance for Structures with Variable Barrier Heights," in CLEO: 2013, OSA Technical Digest (online) (Optical Society of America, 2013), paper JTu1J.7, San Jose, CA (June 2013). http://dx.doi.org/10.1364/CLEO_SI.2013.JTu1J.7
4. J. Lee and M.A. Belkin, "Widely wavelength tunable thermo-optic bandpass filters based on long-range surface plasmon polaritons," in CLEO: 2013, OSA Technical Digest (online) (Optical Society of America, 2014), paper JTu4A.71, San Jose, CA (June 2013). http://dx.doi.org/10.1364/CLEO_AT.2013.JTu4A.71
5. F. Lu, M. Jin, and M.A. Belkin, "Mid-infrared absorption nanospectroscopy via molecular force detection," in CLEO: 2013, OSA Technical Digest (online) (Optical Society of America, 2013), paper QTu1B.1, San Jose, CA (June 2013). http://dx.doi.org/10.1364/CLEO_QELS.2013.QTu1B.1

6. M. A. Belkin, K. Vijayraghavan, A. Vizbaras, A. Jiang, F. Demmerle, G. Boehm, R. Meyer, M.-C. Amann, A. Matyas, R. Chashmahcharagh, P. Lugli, C. Jirauschek, and Z. R. Wasilewski, "THz quantum cascade lasers for operation above cryogenic temperatures", Proc. SPIE **8640,** 864014 San Francisco, CA (Feb. 2013). **(Invited paper)** http://dx.doi.org/10.1117/12.2000858
7. F. Lu, M. Jin, M. Salih, P. Dean, S. Khanna, L.H. Li, G. Davies, E.H. Linfield, and M.A. Belkin, "Terahertz and mid-infrared photoexpansion nanospectroscopy," *Proc. SPIE* **8585,** 858509, San Francisco, CA (Feb. 2013). **(Invited paper)** http://dx.doi.org/10.1117/12.2000743
8. A. Vizbaras, K. Vijayraghavan, F. Demmerle, M. Jang, G. Boehm, R. Meyer, M.A. Belkin, and M.C. Amann, "Mid-wave infrared and terahertz quantum cascade lasers based on resonant nonlinear frequency mixing," *Proc. SPIE* **8631,** 86311V, San Francisco, CA (Feb. 2013). **(Invited paper)** http://dx.doi.org/10.1117/12.2003827
9. K. Vijayraghavan, A. Vizbaras, M. Jang, C. Grasse, G. Boehm, M.C. Amann, and M.A. Belkin, "Terahertz quantum cascade laser sources based on Cherenkov intra-cavity difference-frequency generation," *Proceedings of 2012 IEEE Photonics Conference*, pp. 540-541, Burlingame, CA (Sept. 2012). http://dx.doi.org/10.1109/IPCon.2012.6358732

(c) Conference Presentations Without Proceedings of Full Papers

1. M.A. Belkin, "High performance broadly-tunable terahertz quantum cascade laser sources based on intra-cavity frequency mixing," The 21st International Symposium "Nanostructures: physics and technology," Saint Petersburg, Russia, June 2013. (**Invited talk**)
2. M.A. Belkin, "Nanoscale mid-infrared vibrational spectroscopy with monolayer sensitivity," 96th Canadian Chemistry Conference, Quebec City, Canada, May 30, 2013. (**Invited talk**)
3. M.A. Belkin, "Room-temperature electrically-pumped THz semiconductor sources," US-UK Workshop in Mid-IR to THz Technology and Applications, Edinburgh, UK, February 19, 2013. (**Invited talk**)
4. M. Belkin, K. Vijayraghavan, F. Demmerle, M. Jang, A. Jiang, C. Grasse, and M.-C. Amann, "Room-temperature THz quantum cascade laser sources," Photonics Global Conference, Singapore, December 15, 2012. (**Invited talk**)
5. M. Belkin and F. Lu, "Tip-enhanced mid-infrared and terahertz photoexpansion nanospectroscopy," SciX conference, Kansas City, MO, October 1, 2012. (**Invited talk**)

3. Student Advising

(a) Completed PhD Theses

Names of students and program (e.g. ECE, CS, Physics, etc.)

Min Jang, PhD in ECE, Fall 2012

(b) Current Graduate Advisees

PhD:
1. Mr. Aiting Jiang,
2. Ms. Yifan Jiang
3. Ms. Mingzhou Jin
4. Mr. Jae Hyun Kim
5. Mr. Jongwon Lee,
6. Mr. Feng Lu,
7. Mr. Karun Vijayraghavan

Postdoctoral scholar: Seungyong Jung

Number of graduate students supported by grants, 2012-13	Number of graduate students supported by grants, 2014-15 (*anticipated*)	Number of Ph.D. advisees supported as T.A., Fellow, etc., 2011-12	Number of Ph.D. advisees supported as T.A., Fellow, etc., 2012-13 (*anticipated*)
6 + 1 postdoc	7 + 1 postdoc	1	1

(c) Undergraduate students

I supervised the research of a sophomore student Mr. Karthik Choutagunta in my laboratory in Fall 2012. Karthik focused on the development external cavity laser setup to create widely-tunable quantum cascade lasers. He is a co-author of our 2013 paper on widely-tunable THz sources in Nature Communications.

I am serving as a mentor for the Senior Design Project (EE362D) team in Spring and Fall 2013. The project title "myCAT" is sponsored by National Instruments with the goal of realizing a simple computer-assisted optical tomography system for educational demonstrations. The team consists of students Omar Alatorre, Alan, Lopez, Kevin Nguyen, Robert Payne, and Alfonso Batista.

I also hosted a summer undergraduate student in my group within the NSF National Nanotechnology Infrastructure Network (NNIN) Research Experience for Undergraduate (REU) program. A junior student Priyanka Gaur from Massachusetts Institute of Technology worked in my group from June 2013 to August 2013 on developing voltage-tunable plasmonic metasurfaces.

4. Current Research Projects and Grants

Title, agency, PI, role, amount, duration

1. NSF grant No. ECCS-0925217 **"**COLLABORATIVE RESEARCH: Room-temperature terahertz semiconductor Raman lasers**,"** period 9/1/2009-8/31/2013, PI: Mikhail Belkin, co-PI: Alexey Belyanin (Texas A&M), funding amount $324,987 (my share).
2. NSF grant No. ECCS-1028473 "COLLABORATIVE RESEARCH: Rapidly tunable quantum cascade lasers for FM optical links and spectroscopy," period of performance 9/15/2010-8/31/2014, PI: Gregory Belenky, co-PI: Mikhail Belkin; funding amount **$**224,759 (my share).
3. NSF grant No. ECCS-1150449 "CAREER: Terahertz semiconductor laser sources for operation above cryogenic temperatures," period of performance 5/1/2012-4/31/2017, PI: Mikhail Belkin (single PI), funding amount $400,000.
4. Robert Welch Foundation grant No. F-1705 "Mid-infrared photoacoustic spectroscopy with nanometer resolution using quantum cascade lasers," period 6/1/2012-5/31/2014, PI: Mikhail Belkin (single PI), funding amount $120,000.
5. Texas Higher Education Coordinating Board grant No. 9429 "Short-wavelength quantum cascade lasers with internal frequency doubling," period 7/1/2012-8/31/2014, PI: Mikhail Belkin (single PI), funding amount $80,000.
6. DARPA grant No. 66001-12-14241 ""Room-Temperature High-Power Terahertz Semiconductor Laser Sources," period 8/13/2012-8/12/2014, PI: Mikhail Belkin (single PI), funding amount $300,000.

7. ARO SBIR Phase II (as a sub-contractor to Omega Optics) grant "Monolithic Photonic Crystal On-Chip Spectrometer for Laser Absorption Spectroscopy," period of performance 8/27/2012-5/2/2014, sub-contract from Omega Optics, funding amount $150,000 (my share).
8. DOE STTR Phase II (as a sub-contractor to Anasys Instruments) grant "Resonance-Enhanced Infrared Nanospectroscopy (REINS) based on Atomic Force Microscopy and Quantum Cascade Lasers," period of performance 7/1/2013-6/30/2015, sub-contract from Anasys Instruments, funding amount $150,000 (my share) + another $150,000 are expected to funded in year 2

Total awarded funds since Sept 2008: $**2,481,305** (my share), not counting $150,000 expected to be funding by DOE in year 2 for the project #8.

We are also pursuing a number of small-scale 'exploratory' projects on widely-tunable bandpass filters based on long-range surface plasmon-polaritons, nonlinear optical metasurfaces, sub-wavelength resolution mid-infrared microscopy with Fourier-transform infrared spectrometers, widely-tunable terahertz sources, and others.

5. Proposal Submissions

Pending proposals:

1. NSF grant "EAGER: Highly-nonlinear metasurfaces low-intensity nonlinear optics," suggested period of performance 10/1/2013-3/30/2015, PI: Mikhail Belkin, co-PI: Andrea Alu; requested amount $120,000 (my share).
2. Hamamatsu Photonics (Japan) "Room-temperature Continuous-Wave Terahertz Quantum Cascade Laser Sources," suggested period of performance 9/1/2013-8/31/2015, PI: Mikhail Belkin (single PI), requested amount $100,000.
3. Naval Research Office SBIR with Omega Optics "Chip-Integrated In-Situ, Remote, Continuous Oil Condition Monitor and Debris Sensing System" 10/1/2013 - 09/30/2014, requested amount 28,331 (my share).

B. Teaching

6. Special Projects, Lab and Course Developments, etc.

Developed (Fall 2009) and improved (Fall 2010, Fall 2011, Spring 2013) 'Nonlinear Optics' course (EE 383V) for graduate students

C. Service Activities

7. University Service

Member of the 'Transition committee' at the ECE department
Member of the 'Seminar committee' at the ECE department

SSE area coordinator

8. Technical Society Service

Co-chair for the 12th International Conference on Intersubband Transitions in Quantum Wells (September 2013).

IEEE Photonics Society Central Texas Chapter Chair.

Reviewed papers for Nature Photonics, Nature Communications, IEEE Journal of Quantum Electronics, Applied Physics Letters, Optics Express, and other journals.

Session chair: CLEO conference, Baltimore, MD (June 2013), Photonics West (Februar 2013), Photonics Global (December 2012).

D. Other Items of Interest

E. Plans for the Coming Year

The main objective for the coming year is to produce high-quality and high-impact-factor research results in the fields of mid-infrared and THz quantum cascade lasers, microscopy, plasmonics, and metamaterials. In particular, we aim to produce the first semiconductor laser source of terahertz radiation with continuous wave room temperature operation (we recently demonstrated pulsed operation at room temperature) and measure its emission linewidth, demonstrate novel nonlinear metasurfaces based on intersubband polaritons, and achieve close to single molecule sensitivity with our novel mid-IR microscopy system. We will make an effort to publish our best results in the best journal in the field (Nature-family journals, Science).

Securing additional funding for group expansion is another goal. We hope to secure enough funding to expand the group by 1 more student next year.

BC Statement on Teaching for Dr. Mikhail Belkin

Principal Areas of Teaching

Professor Belkin's principal area of teaching is solid-state electronics, with an emphasis on optoelectronics. Optoelectronics is the study and application of electronic devices that source, control, and detect light. Professor Belkin's graduate teaching and research interests relate to: (a) the development of terahertz quantum cascade lasers, using engineered optical nonlinearities and intra-cavity frequency mixing to extend the spectral range of quantum cascade lasers to near infrared and terahertz, (b) developing mid-infrared and terahertz photonic components and systems for chemical sensing, and (c) developing and studying metamaterials in mid-infrared.

His undergraduate teaching is in the area of electromagnetic engineering, which involves the physical aspects of modern communication and radar systems. In particular, the electromagnetic engineering is concerned with the physical mechanisms of the transmission medium and the design of transmission structures to deliver information from one location to another. The study of electromagnetic engineering provides the natural linkage between the Telecommunications and Signal Processing area and the Electronics Materials and Devices area. The background gained by the students in this area is essential preparation for Professor Belkin's graduate courses in optoelectronics.

Teaching Evaluation Procedures and Measures

The department employs two methods to evaluate teaching performance: Course Instructor Surveys and Peer Observations of Classroom Instruction. The course instructor surveys are conducted in the last three weeks of lecture in every course. A peer evaluation was carried out by a full professor after a visit to the classroom. The time and date of the visit was agreed on between the instructor and the evaluator beforehand.

Summary of Courses Taught and Course Instructor Surveys

As an Assistant Professor, Dr. Belkin has developed and taught two new graduate courses, EE396V "Nanostructured Optoelectronic" and EE383V "Nonlinear Optics;" and taught an undergraduate course, EE325 "Electromagnetic Engineering."

EE325 "Electromagnetic Engineering" is an introductory course on electromagnetic theory and principles. Electromagnetics, or "field theory" provides the fundamental basis for much of electrical engineering. Direct engineering applications of electromagnetics include antennas, radio wave propagation, radar sensors, microwave and RF circuitry. In addition, electromagnetics has close ties to communication systems, opto- and solid-state electronics, circuit design and power systems. The course typically involves electrostatics, magnetostatics and electrodynamics.

EE396V "Nanostructured Optoelectronic" is a graduate course that studies the physics and performance aspects of modern optoelectronic devices that utilize quantum confinement of electrons in semiconductor nanostructures (with the focus on understanding and the operation of these devices based on their energy band diagrams). It covers advanced topics such as quantum wells, quantum dots and superlattices, calculation of quantum states, quantum size effect in Nanostructures, quantum-confined Stark effect, quantum well and quantum dot lasers, quantum

well infrared photodetectors, quantum cascade lasers, and solar cells that utilize semiconductor nanostructures.

EE383V "Nonlinear Optics" is a graduate course that studies the principles of nonlinear optics, the operation of photonic devices, and systems that utilize various nonlinear optical effects. It covers advanced topics such as nonlinear optical susceptibility of materials, origin of optical nonlinearities, symmetry properties of nonlinear susceptibility tensors, coupled-wave equations, second harmonic, sum- and difference-frequency generation, phase-matching condition and techniques to achieve phase matching, parametric amplification, electro-optic effect, multi-photon absorption, self-focusing and self-phase modulation, optical solitons, Raman amplification, and acousto-optic effect. The course also covers nonlinear optical devices such as optical parametric oscillators, harmonic generation systems, mid-infrared and THz sources based on difference frequency generation, optical switches, and Raman lasers.

The primary indicator on the Course Instructor Surveys used to evaluate teaching performance is the Overall Instructor Rating. The average overall instructor rating in the ECE department is 3.7 for undergraduate courses and 4.1 for graduate courses. The overall instructor rating is typically greater than or equal to the course rating. The table below summarizes the instructor and course ratings for all courses Professor Belkin has taught while in rank.

Course	U/G	Semester	No. of Surveys	Overall Instructor	Overall Course
EE 396V Nanostructured Optoelectronic	G	Spring 09	4	4.3	4.0
EE 383V Nonlinear Optics	G	Fall 09	18	4.1	3.7
EE 325 Electromagnetic Engineering	U	Spring 10	26	3.7	3.3
EE 383V Nonlinear Optics	G	Fall 10	9	4.7	4.7
EE 325 Electromagnetic Engineering	U	Spring 11	69	3.5	3.2
EE 383V Nonlinear Optics	G	Fall 11	14	4.0	3.9
EE 325 Electromagnetic Engineering	U	Spring 12	45	3.8	3.4
EE 383V Nonlinear Optics	G	Spring 13	4	5.0	4.8

As an Assistant Professor , Dr. Belkin has developed and taught two new graduate courses, EE396V "Nanostructured Optoelectronic," and EE 383V "Nonlinear Optics"; and an undergraduate course, EE325 "Electromagnetic Engineering." The class size has been 4-18 for the graduate classes and 21-69 for the undergraduate classes. His course instructor rating are very good, especially for his graduate courses – an average score of 4.3/5 for his graduate course EE396V, an average score of 4.45/5 for EE383V and 3.7/5 for EE325. This is very good especially considering that EE325 is a required class and many of the students do not really want to be there. His rating in EE325 is well above the average among all other instructors who have taught the course in recent years. The course is a challenge for all concerned.

Summary of Peer Observation of Classroom Instruction

I personally conducted peer observation of Professor Belkin's classroom instruction of EE383V "Nonlinear Optics" on April 16, 2013 (please see the attached reports for details). Based on my observations, Professor Belkin is an excellent lecturer who presents the material in a clear, concise and logical manner. It was very apparent that Professor Belkin is an expert in the field. He paced the lecture appropriately and effectively used PowerPoint slides and the white board. It was also obvious that he has spent a great deal of time outside the classroom, both in preparing for the class and answering questions during his office hours.

Teaching Portfolio

Professor Belkin's teaching portfolio demonstrates a set of well-prepared and developed course materials, including syllabi, handouts, homework and exams. It is very apparent that he has spent a great deal of time outside the classroom in preparing for the classes and interacting with his students. Since he and I are both in the Microelectronics Research Center, we periodically discuss research and teaching. My interaction with him, along with his teaching statement, indicate that he is a devoted teacher who cares a great deal about his students' learning.

Individual Instruction

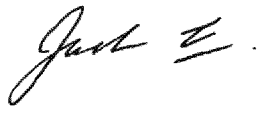
As an Assistant Professor, Dr. Belkin has graduated 1 Ph.D. student with 7 more in progress. He has also supervised 3 undergraduates and 2 postdoctoral fellows. The PhD student graduate is now working as an electrical engineer for Samsung Electronics Corporation in Korea. His 3 undergraduate students are working on a project sponsored by Pecan Street, Inc., with the goal of realizing a system for residential power factor correction. Under his leadership, his graduate research assistants have been very productive in terms of publications, research results, and recognition (see his Research Statement). Note that he does not actively pursue M.S. only students. In his area of research (i.e., experimental and theoretical work on photonic system in mid-infrared and terahertz range), the learning curve is simply too long.

Professor Belkin also participates in the NSF National Nanotechnology Infrastructure Network Research Experience for Undergraduates Program (NNIN REU), which invites undergraduate students from all over U.S.A. to perform research in the Microelectronics Research Center at The University of Texas at Austin. Professor Belkin has hosted three summer NNIN REU undergraduate students from 2011-13. These students learned a great deal about scientific research through hands-on experience and interaction with Professor Belkin.

Summary

As an Assistant Professor, Professor Belkin has delivered quality teaching at both graduate and undergraduate levels. At the undergraduate level, he is devoted to his EE325 course, senior projects, and the NSF National Nanotechnology Infrastructure Network Research Experience for Undergraduates Program. At the graduate level, he has developed two new courses and done an excellent job in advising his research students. His teaching performance has clearly exceeded the standards for promotion to Associate Professor.

Summary Prepared by Budget Council Member Professor Jack Lee.



Teaching Statement

Mikhail A. Belkin
Department of Electrical and Computer Engineering, The University of Texas at Austin
mbelkin@ece.utexas.edu

I believe teaching and course development are the key responsibilities of a faculty member. I devote a large amount of time and effort to teaching, and enjoy being in the classroom and interacting with students. Since the start of my career at The University of Texas at Austin, I have developed two new graduate-level courses, taught large required undergraduate classes, and supervised senior-design projects. I served as a research advisor to three undergraduate students, nine graduate students, and two postdoctoral scholars in my research group in addition to supervising summer undergraduate and MS students under different programs run by the National Science Foundation (NSF) and the University of Texas as described below.

1. *Summary of teaching activities*

I have taught a total of eight classes at the University of Texas. I have developed and taught two new graduate courses: EE 396V "Nanostructured Optoelectronics" (taught in Spring 2008) and EE 383V "Nonlinear Optics" (taught in Fall 2009, Fall 2010, Fall 2011 and Spring 2013). I also taught a required upper division undergraduate course EE 325 "Electromagnetic Engineering" in Spring 2010, Spring 2011, and Spring 2012.

The table shown below summarizes the enrollment and evaluations for all courses. Note that the 3-year average of an instructor/course score for all sections of EE 325 "Electromagnetic Engineering" course taught in our department is 3.7/3.4.

STUDENT COURSE EVALUATIONS (FIVE POINT SCALE)

Academic Year	Fall Semester				Spring Semester			
	Course	Enroll	Instructor Evaluation	Course Evaluation	Course	Enroll	Instructor Evaluation	Course Evaluation
12/13	Modified instructional duties				EE 383V	4	5.0	4.8
11/12	EE 383V	14	4.0	3.9	EE 325	45	3.8	3.4
10/11	EE 383V	9	4.7	4.7	EE 325	69	3.5	3.2
09/10	EE 383V	18	4.1	3.7	EE 325	26	3.7	3.3
08/09	Modified instructional duties				EE 396V	4	4.3	4.0

A few excerpts from recent course evaluations are provided below: "Outstanding Professor. Thanks" (EE 383V Fall 2011), "Good and helpful course" (EE 383V Fall 2011), "The Professor teaches very well and the material is well-organized. Office hours are extremely helpful too" (EE 325, Spring 2012), "Knowledgeable and enthusiastic about the material" (EE 325, Spring 2012).

I supervised a three-person senior design project team in the Spring and Summer semesters of 2012. The project was sponsored by Pecan Street, Inc. with the goal of realizing a system for

residential power factor correction. I am now supervising another senior design project team of five people. The project that spans the Spring and Fall semesters of 2013 is sponsored by National Instruments Corporation with the goal of realizing a computer-assisted optical tomography system. I also served or I am currently serving as a research advisor to three undergraduate students, nine graduate students, and two postdoctoral scholars in my laboratory.

Additionally, I hosted three summer undergraduate students under the NSF National Nanotechnology Infrastructure Network Research Experience for Undergraduates program in my laboratory, and I am currently serving as Master's thesis supervisor for a high school teacher taking UTeachEngineering Master of Arts in Science, Technology, Engineering, and Mathematics Education.

Finally, I have served on 12 doctoral candidacy and 7 Ph.D. defense committees.

2. *Teaching Methodologies*

Whenever I teach students a new concept, I try to present a physical picture first and then introduce the equations that would describe the process mathematically. For example, for undergraduate students, I explain that electrostatic potential energy is similar to a classical potential energy or the work that one does to bring a heavy object up a hill. That current is a flow of free electrons (charged particles) moving in the presence of friction (similar to air drag) as a result of an externally applied electrostatic force. This approach extends to graduate courses as well, where I try to first introduce very simple classical examples and then extend these examples with quantum-mechanical or electromagnetic formalism to mathematical equations.

I begin lectures with a short recap of the previous material related to the topic to set new material in perspective. I encourage students to interact with me and each other during lectures and ask questions to gauge their understanding of the material. For both undergraduate and graduate lectures I display Power Point slides with the summary of a problem and key equations and then derive the solution on the board. I also use Power Point slides when visualization is important in grasping the concept. The slides are available for download before class, so that students can use them in class to make notes and later used them as a reference.

For graduate courses, I illustrate the application of many concepts that we cover with examples from recent research articles. For the undergraduate course, I try to follow a somewhat similar approach, but in a simplified and more entertaining fashion. For example, in an undergraduate Electromagnetic Engineering class, I show videos of Andre Geim's levitating frog and other objects when we discuss magnetic materials, and I tell them how the first measurements of the speed of light were done by observing eclipses of Jupiter moons and by measuring parallax of Mars to determine the size of the solar system.

For undergraduate classes, I assign homework questions every week and have three midterm exams in addition to the final exam to keep students focused during the duration of the course. For graduate courses, I usually give homework every two weeks and have one or two midterms, but not a final exam. Instead of a final exam, the students write a term paper and give a 25-minute presentation on an experiment or a technique that uses the concepts covered in class (for my Nonlinear Optics class these are various nonlinear optical phenomena). The presentation and the discussion that follows give students broad perspectives on where the knowledge that they got in class may be applied.

3. *Course development*

Since joining the University of Texas in Fall 2008 I have developed two new graduate courses, EE 396V "Nanostructured Optoelectronics," and EE 383V "Nonlinear Optics." In addition to developing these courses, I taught EE 325 "Electromagnetic Engineering," for which I used a combination of lecture notes I developed with lecture notes from instructors who had previously taught the course.

The first course I developed at the University of Texas was the graduate course EE 396V "Nanostructured Optoelectronics," which I first taught in the Spring of 2009. This course focuses on the physics and performance aspects of modern optoelectronic devices that utilize quantum confinement of electrons in semiconductor nanostructures. The course covers semiconductor heterostructures, quantum wells, quantum dots and superlattices, calculation of quantum states, quantum size effect in nanostructures, quantum-confined Stark effect, quantum well and quantum dot lasers, intersubband transitions, quantum well infrared photodetectors, and quantum cascade lasers. The theoretical concepts covered in the course were illustrated with results from recent research articles.

The second graduate course that I developed is EE 383V "Nonlinear Optics." This course covers an important gap in photonics course program in our department that did not have a dedicated nonlinear optics class. The class is based on Robert Boyd's "Nonlinear Optics" textbook and it covers a wide variety of nonlinear optical phenomena, including second harmonic, sum- and difference-frequency generation, phase-matching and techniques to achieve phase matching, parametric amplification, electro-optic effect, multi-photon absorption, self-focusing and self-phase modulation, optical solitons, stimulated Raman scattering and Raman amplification, optical phase conjugation, optical bistability, acousto-optic effect, and Brillouin scattering. In addition, it covers some fundamental topics of nonlinear optics such as origin of optical nonlinearities, symmetry properties of nonlinear susceptibility tensors, and quantum mechanical derivation of nonlinear coefficients. The course includes many examples of nonlinear optical devices to illustrate theoretical material, including optical parametric oscillators, harmonic generation systems, mid-infrared and THz sources based on difference-frequency generation, optical switches, Raman lasers, quantum cascade lasers with internal frequency conversion, lasers without inversion, self-mode-locked femtosecond lasers, and acousto-optic modulators. This course attracts not only students from our department but a significant number of students from Physics, Chemistry, and Biomedical Engineering departments as well.

4. *Individual Instruction*

Supervising my research group members is an important part of teaching. I have supervised or I am supervising three UT undergraduates, nine graduate students, and two postdoctoral fellows in my group. I have graduated one Ph.D. student who is now working as an Electrical Engineer for Samsung Electronics Corporation in Korea and one MS student who is currently working as Product Development Electrical Engineer in Baker Hughes in Houston, TX. I am currently advising four Ph.D. students with one in candidacy, three M.S. students (all are planning to continue on to get their Ph.D. in my group), and one postdoctoral scholar. I spend a large amount of time with each student and postdoc in my group and I monitor their progress closely. In many cases, they learn the experimental techniques from me as we 'turn knobs' together in the lab. Postdoctoral scholars in my group are encouraged to supervise junior graduate students and develop their research projects together. This gives postdoctoral scholars an opportunity to practice

supervisions skills and increases their productivity while graduate students learn new skills from the postdoctoral scholars. I also encourage my senior graduate students to mentor and advise our more junior students.

I actively participate in the NSF National Nanotechnology Infrastructure Network Research Experience for Undergraduates Program (NNIN REU) with undergraduate students from all over the country performing research in my laboratory in the summers. So far I have hosted three summer NNIN REU undergraduate students in 2011, 2012, and 2013.

I also encourage undergraduate students in our department to participate in our laboratory research. I have had three undergraduate students from our department working in my laboratory. One of them, Karthik Choutagunta, received the R. W. and Kathleen Lindsey Endowed Presidential Scholarship in Summer 2012 thanks, in part, to his research experience in my laboratory. He is also a co-author of our 2013 paper in Nature Communications.

Finally, this year, I am also participating in the UTeachEngineering Master of Arts in Science, Technology, Engineering, and Mathematics Education as a Master's Thesis research supervisor for a high school teacher Kari Bennett working towards her MA degree.

List of Current and Former PhD Students, MS Students, and Postdoctoral Scholars Supervised

PH.D. SUPERVISIONS COMPLETED:

Jang, Min	Dec. 2012	Quantum cascade laser sources based on intra-cavity frequency mixing	Electrical and Computer Engineering	The University of Texas at Austin

M.S. SUPERVISIONS COMPLETED:

Adams, Robert	Dec. 2011		Electrical and Computer Engineering	The University of Texas at Austin

PH.D. IN PROGRESS:

A. Students admitted to candidacy

1. Karun Vijayraghavan (Department of Electrical and Computer Engineering)

B. Post M.S. students preparing to take Ph.D. qualifying exam

1. Feng Lu (Department of Electrical and Computer Engineering)
2. Jongwon Lee (Department of Electrical and Computer Engineering)
3. Aiting Jiang (Department of Electrical and Computer Engineering)

M.S. IN PROGRESS
(All of my MS students plan to continue working towards PhD in my group):

1. Yifan Jiang (Department of Electrical and Computer Engineering)
2. Mingzhou Jin (Department of Electrical and Computer Engineering)
3. Jae Hyun Kim (Department of Electrical and Computer Engineering)

POSTDOC IN PROGRESS:

1. Seungyong Jung (Department of Electrical and Computer Engineering)

POSTDOC COMPLETED:

1. David Austin (Department of Electrical and Computer Engineering)

All of my MS and PhD students are financially supported by research assistantships, teaching assistantships, or fellowships.

List of Supervising Committees

Qualifying Examination Committees

1. Joo-Yun Jung, Department of Electrical and Computer Engineering, The University of Texas at Austin.
2. Amir Hosseini, Department of Electrical and Computer Engineering, The University of Texas at Austin.
3. Adam Michael Crook, Department of Electrical and Computer Engineering, The University of Texas at Austin.
4. Biwei Yin, Department of Electrical and Computer Engineering and Department of Biomedical Engineering, The University of Texas at Austin.
5. Hari P. Nair, Department of Electrical and Computer Engineering, The University of Texas at Austin.
6. Min Jang, Department of Electrical and Computer Engineering, The University of Texas at Austin. **(Supervisor)**
7. Yang Zhao, Department of Electrical and Computer Engineering, The University of Texas at Austin.
8. Hoo Kim, Department of Electrical and Computer Engineering, The University of Texas at Austin.
9. John Covey, Department of Electrical and Computer Engineering, The University of Texas at Austin. **(Chair)**
10. Karun Vijayraghavan, Department of Electrical and Computer Engineering, The University of Texas at Austin. **(Supervisor)**
11. Jingsi Li, Department of Electrical and Computer Engineering, The University of Texas at Austin.
12. Rodolfo Salas, Department of Electrical and Computer Engineering, The University of Texas at Austin.

PhD Defense Committees

1. Joo-Yun Jung, Department of Electrical and Computer Engineering, The University of Texas at Austin.
2. Amir Hosseini, Department of Electrical and Computer Engineering, The University of Texas at Austin.
3. Adam Michael Crook, Department of Electrical and Computer Engineering, The University of Texas at Austin.
4. Min Jang, Department of Electrical and Computer Engineering, The University of Texas at Austin. **(Supervisor)**
5. Hari P. Nair, Department of Electrical and Computer Engineering, The University of Texas at Austin.
6. Pai-Yen Chen, Department of Electrical and Computer Engineering, The University of Texas at Austin.
7. Yang Zhao, Department of Electrical and Computer Engineering, The University of Texas at Austin.

Summary Tables

Table 1. Teaching Summary

Metric	Value
Weighted Average UG Course GPA	2.74
# of Students Taught	189
Average Instructor Evaluation (2008-2013)	3.9
Average Instructor Evaluation (last 3 years)	3.89
# of Teaching Awards	None
PhD Students Completed *	1 (1 sole advisor)
MS Students Completed *	1 (1 as sole advisor)
PhD Students in Pipeline (as of 09/2013) *	4 (4 as sole advisor)
MS Students in Pipeline (as of 09/2013) *	3 (3 as sole advisor)

*count 1 if sole advisor, 0.5 if co-advised

Table 2. Course schedule by semester in ECE since 2008; number of students indicated.

Course	F 08	S 09	F 09	S 10	F 10	S 11	F 11	S 12	F 12	S 13
EE 325				26		69		45		
EE 383V			18		9		14			4
EE 396V		4								

*Shaded boxes indicate modified instructional duties

Table 3. Summary of Current Graduate Students Supervised at UT-Austin

Student	Co-Supervisor	Degree	Start	Expected
Seungyong Jung	none	PostDoc	2/2013	2/2015
Karun Vijayraghavan	none	PhD	09/2008	Spring 2014
Aiting Jiang	none	PhD	09/2008	Spring 2015
Feng Lu	none	PhD	09/2009	Spring 2015
Jongwon Lee	none	PhD	01/2009	Spring 2015
Yifan Jiang	none	MS	09/2011	Spring 2013
Mingzhou Jin	none	MS	09/2012	Spring 2014
Jae Hyun Kim	none	MS	09/2012	Spring 2014

4/18/2012

Assistant Professor Mikhail Belkin
EE 325 Electromagnetic Engineering
Evaluation by Leonard Franklin Register

Classroom Review:

This semester Prof. Belkin is currently teaching his EE 325 Electromagnetic Engineering class, Monday, Wednesday and Friday in Waggener Hall, Room 420 from 11:00 to 11:50 AM.

For background, this course is a junior level introductory course in electromagnetics, and within the current catalog it is required for all students within the Electrical Engineering side of Electrical and Computer Engineering. (To the extent that there may still be students working on the old catalog, it was required of all ECE students.) The basic course description as included in the undergraduate catalog is:

> Introduction to electrostatics and magnetostatics; properties of conductive, dielectric, and magnetic materials; solutions of Maxwell's equations; uniform plane wave applications; frequency-and time-domain analyses of transmission lines. Prerequisite: Physics 303L, 103N, and Mathematics 427K with a grade of at least C- in each, and credit with a grade of at least C- or registration for Mathematics 427L.

As apparent from the description, the course material is substantially physics-oriented in nature, and in this way represents a significant shift away from the more abstract material presented in ECE classes up to this point. From what I hear from students, independent of who teaches the course, this course, EE 339, Solid State Electronic Devices (also very physics oriented) and 351K, Probability and Random Processes represent perhaps the most conceptually challenging courses in the curriculum.

On the day I attended, March 27th, Professor Belkin was explaining methods of calculating magnetic fields produced by charge current distributions. He used what I consider an excellent mix of PowerPoint Slides and writing on the (actual) backboard Critical results along with associated well-crafted figures were presented on the Foils; derivations, explanations and examples were presented on the board in a step-by-step fashion. (I understand through subsequent discussion with prof. Belkin, that this style with less reliance on PowerPoint foils is a style he has moved to recently, with positive feedback from the students.) From my position in the back and off to the side, I had no trouble hearing him or seeing his writing and drawing. I found the explanations and examples to be clear and concise and focused on what I know to be critical points, and the free-hand drawn figures to be quite good—where the achieving the latter is not easy for the considered multi-dimensional systems—and his analogies to previous results to be informative. From my perspective, he seemed to do an excellent job of translating results that can only be described mathematically via vector calculus (integral and derivative) into a clear physically picture.

The class also seemed to understand and to be learning effectively at a good pace, appearing neither bowled-over nor bored. Looking around the class, all but one of the students were focused on Prof. Belkin or writing. His interaction with the class seemed quite good, helped along by his relaxed style. Prof. Belkin readily handled questions from students, and students

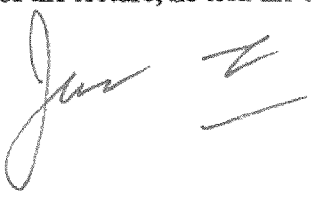
willingly tackled questions he asked. The class attendance itself of approximately 75% that day (approximately 30 students attending in a class of just over 40 students at last check) is good I believe, particularly for someone who makes his PowerPoint foils available to students on the internet.

Classroom Review of Mikhail Belkin by Jack Lee

On April 16, 2013, I personally attended Dr. Belkin's lecture during his EE 383V: Nonlinear Optics course. The topics for that lecture was "all-optical switching, Brillouin scattering and acoustooptics". This is a graduate special-topic course and the class size is small. Only 4 students attended that day.

In my opinion, a good lecturer presents the material in a clear, concise and logical manner; demonstrates an expert knowledge in the subject; generates excitement and curiosity about the material; shows genuine interest in students' learning; encourages questions and interaction with students; paces the lecture appropriately; uses presentation tools effectively; includes materials outside of the textbooks; provides summary of the lecture at the end of the lecture. Obviously, a good teacher does much more outside the lecture.

Based on my observation on that particular lecture, I believe that Dr. Belkin is a good lecturer. It was obvious that Belkin is an expert in the subject matter. He presented his materials in a clear, concise and logical sequence. The students were very engaged to his lecture and there were a great deal of interaction with at least 5 questions from the students. He paused periodically and asked if there were any questions or comments on the materials. He used both the PowerPoint slides and the white board effectively. The slides were well prepared and it was obvious the slides cover materials not readily accessible in the textbook. He must have spent many hours preparing those slides. At the end of the lecture, he told the class about the upcoming classes.



Summary of Recent (All Years In Rank) UT Austin Course-Instructor Survey Resul
Overall Course/Instructor Items

Semester	Course Number	Course Title	Enrollment		Instructor Averages*		College/School Averages**		
			No. of Students Enrolled on 12th Class Day	No. of Surveys Returned at End of Semester	Overall Instructor Rating Avg.	Overall Course Rating Avg.	Overall Instructor Rating Avg.	Overall Course Rating Avg.	No. Classes Surveyed
Spring 09	E E 396V	NANOSTRUCTURED OPTOELECTRONICS	4	3	4.3	4.0	N/A ***	N/A ***	N/A
Fall 09	E E 383V	NONLINEAR OPTICS	18	15	4.1	3.7	N/A ***	N/A ***	N/A
Spring 10	E E 325	ELECTROMAGNETIC ENGINEERING	26	12	3.7	3.3	N/A ***	N/A ***	N/A
Fall 10	E E 383V	NONLINEAR OPTICS	9	9	4.7	4.7	N/A ***	N/A ***	N/A
Spring 11	E E 325	ELECTROMAGNETIC ENGINEERING	69	29	3.5	3.2	N/A ***	N/A ***	N/A
Fall 11	E E 383V	NONLINEAR OPTICS	14	12	4.0	3.9	N/A ***	N/A ***	N/A
Spring 12	E E 325	ELECTROMAGNETIC ENGINEERING	45	33	3.8	3.4	N/A ***	N/A ***	N/A
Spring 13	E E 383V	NONLINEAR OPTICS	4	4	5.0	4.8	N/A ***	N/A ***	N/A

*For the computation of the averages, points were assigned to student responses as follows:
Excellent = 5, Very Good = 4, Satisfactory = 3, Unsatisfactory = 2, Very Unsatisfactory = 1

**College/school averages are the average of class averages, based on all courses surveyed in the instructor's college or school during the academic year in which the course was taught.

***New CIS forms were implemented in the fall 2000 semester. The average rating on the overall course and instructor questions on the new Basic and Expanded forms have been found to be approximately 0.1 to 0.2 points lower than those ratings on the old Common form.

Prepared by the Measurement and Evaluation Center

*** PROVISIONAL REPORT ***

UNIVERSITY OF TEXAS AT AUSTIN
Belkin, Mikhail A E E383V 16910
B000 Basic

COURSE-INSTRUCTOR SURVEY
NONLINEAR OPTICS

Spring 2013 DEPARTMENT COPY
Enrollment = 4
Surveys Returned = 4

	NUMBER CHOOSING EACH RESPONSE					NO. REPLIES THIS ITEM	AVG.
	Str Disag	Disagree	Neutral	Agree	Str Agree		
1 COURSE WELL-ORGANIZED	0	0	0	1	3	4	4.8
2 COMMUNICATED INFORMATION EFFECTIVELY	0	0	1	1	2	4	4.3
3 SHOWED INTEREST IN STUDENT PROGRESS	0	0	0	0	4	4	5.0
4 ASSIGNMENTS AND TESTS RETURNED PROMPTLY	0	0	0	2	2	4	4.5
5 STUDENT FREEDOM OF EXPRESSION	0	0	0	0	4	4	5.0
6 COURSE OF VALUE TO DATE	0	0	0	0	4	4	5.0
	Vry Unsat	Unsat	Satisfact	Very Good	Excellent		
7 OVERALL INSTRUCTOR RATING	0	0	0	0	4	4	5.0
8 OVERALL COURSE RATING	0	0	0	1	3	4	4.8
	Excessive	High	Average	Light	Insuffic		
9 STUDENT RATING OF COURSE WORKLOAD	0	1	3	0	0	4	
	Less 2.00	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00		
10 OVERALL UT GRADE POINT AVERAGE	0	0	0	2	2	4	
	A	B	C	D	F		
11 PROBABLE COURSE GRADE	2	2	0	0	0	4	

For the computation of averages, values were assigned on a 5-point scale so that the most favorable response was assigned a value of 5 and the least favorable response was assigned a value of 1.

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UNIVERSITY OF TEXAS AT AUSTIN
Belkin, Mikhail A E E325 16335
BOOO Basic

COURSE-INSTRUCTOR SURVEY
ELECTROMAGNETIC ENGINEERING

Spring 2012 DEPARTMENT COPY
Enrollment = 42
Surveys Returned = 33

	NUMBER CHOOSING EACH RESPONSE					NO. REPLIES THIS ITEM	AVG.
	Str Disag	Disagree	Neutral	Agree	Str Agree		
1 COURSE WELL-ORGANIZED	0	2	0	16	15	33	4.3
2 COMMUNICATED INFORMATION EFFECTIVELY	1	2	5	18	7	33	3.8
3 SHOWED INTEREST IN STUDENT PROGRESS	0	3	9	13	8	33	3.8
4 ASSIGNMENTS AND TESTS RETURNED PROMPTLY	0	0	3	10	20	33	4.5
5 STUDENT FREEDOM OF EXPRESSION	0	1	5	7	20	33	4.4
6 COURSE OF VALUE TO DATE	2	2	7	11	11	33	3.8
	Vry Unsat	Unsat	Satisfact	Very Good	Excellent		
7 OVERALL INSTRUCTOR RATING	0	4	6	14	9	33	3.8
8 OVERALL COURSE RATING	2	4	12	8	7	33	3.4
	Excessive	High	Average	Light	Insuffic		
9 STUDENT RATING OF COURSE WORKLOAD	0	7	22	2	1	32	
	Less 2.00	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00		
10 OVERALL UT GRADE POINT AVERAGE	0	2	6	10	14	32	
	A	B	C	D	F		
11 PROBABLE COURSE GRADE	4	18	9	1	0	32	

For the computation of averages, values were assigned on a 5-point scale so that the most favorable response was assigned a value of 5 and the least favorable response was assigned a value of 1.

Scanned: 05/24/2012

Printed: 07/17/2012

Student comments (if available):

UNIVERSITY OF TEXAS AT AUSTIN
Belkin, Mikhail A E E383V 17235
8000 Basic

COURSE-INSTRUCTOR SURVEY
NONLINEAR OPTICS

Fall 2011 DEPARTMENT COPY
Enrollment = 13
Surveys Returned = 12

	NUMBER CHOOSING EACH RESPONSE					NO. REPLIES THIS ITEM	AVG.
	Str Disag	Disagree	Neutral	Agree	Str Agree		
1 COURSE WELL-ORGANIZED	0	1	2	3	6	12	4.2
2 COMMUNICATED INFORMATION EFFECTIVELY	0	0	2	5	5	12	4.3
3 SHOWED INTEREST IN STUDENT PROGRESS	1	1	1	3	6	12	4.0
4 ASSIGNMENTS AND TESTS RETURNED PROMPTLY	0	3	3	3	3	12	3.5
5 STUDENT FREEDOM OF EXPRESSION	0	1	1	4	6	12	4.3
6 COURSE OF VALUE TO DATE	0	1	0	5	6	12	4.3
	Vry Unsat	Unsat	Satisfact	Very Good	Excellent		
7 OVERALL INSTRUCTOR RATING	0	1	3	3	5	12	4.0
8 OVERALL COURSE RATING	0	1	3	4	4	12	3.9
	Excessive	High	Average	Light	Insuffic		
9 STUDENT RATING OF COURSE WORKLOAD	0	3	6	1	1	11	
	Less 2.00	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00		
10 OVERALL UT GRADE POINT AVERAGE	0	0	0	2	7	9	
	A	B	C	D	F		
11 PROBABLE COURSE GRADE	6	5	0	0	0	11	

For the computation of averages, values were assigned on a 5-point scale so that the most favorable response was assigned a value of 5 and the least favorable response was assigned a value of 1.

Scanned: 12/20/2011

Printed: 07/16/2012

Student comments (if available):

UNIVERSITY OF TEXAS AT AUSTIN
Belkin, Mikhail A E E325 16405
8000 Basic

COURSE-INSTRUCTOR SURVEY
ELECTROMAGNETIC ENGINEERING

Spring 2011 DEPARTMENT COPY
Enrollment = 67
Surveys Returned = 29

	NUMBER CHOOSING EACH RESPONSE					NO. REPLIES THIS ITEM	AVG.
	Str Disag	Disagree	Neutral	Agree	Str Agree		
1 COURSE WELL-ORGANIZED	0	1	2	18	8	29	4.1
2 COMMUNICATED INFORMATION EFFECTIVELY	0	5	1	15	8	29	3.9
3 SHOWED INTEREST IN STUDENT PROGRESS	1	0	8	10	10	29	4.0
4 ASSIGNMENTS AND TESTS RETURNED PROMPTLY	0	2	3	16	8	29	4.0
5 STUDENT FREEDOM OF EXPRESSION	0	0	6	11	12	29	4.2
6 COURSE OF VALUE TO DATE	0	4	7	11	7	29	3.7
	Vry Unsat	Unsat	Satisfact	Very Good	Excellent		
7 OVERALL INSTRUCTOR RATING	0	5	9	11	4	29	3.5
8 OVERALL COURSE RATING	0	7	11	9	2	29	3.2
	Excessive	High	Average	Light	Insuffic		
9 STUDENT RATING OF COURSE WORKLOAD	0	3	25	1	0	29	
	Less 2.00	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00		
10 OVERALL UT GRADE POINT AVERAGE	0	1	7	5	16	29	
	A	B	C	D	F		
11 PROBABLE COURSE GRADE	7	18	4	0	0	29	

For the computation of averages, values were assigned on a 5-point scale so that the most favorable response was assigned a value of 5 and the least favorable response was assigned a value of 1.

Scanned: 05/19/2011

Printed: 09/11/2012

Student comments (if available):

UNIVERSITY OF TEXAS AT AUSTIN
Belkin, Mikhail A E E383V 17020
8000 Basic

COURSE-INSTRUCTOR SURVEY
NONLINEAR OPTICS

Fall 2010 DEPARTMENT COPY
Enrollment = 9
Surveys Returned = 9

	NUMBER CHOOSING EACH RESPONSE					NO. REPLIES THIS ITEM	AVG.
	Str Disag	Disagree	Neutral	Agree	Str Agree		
1 COURSE WELL-ORGANIZED	1	0	1	0	7	9	4.3
2 COMMUNICATED INFORMATION EFFECTIVELY	1	0	1	1	6	9	4.2
3 SHOWED INTEREST IN STUDENT PROGRESS	1	0	1	2	5	9	4.1
4 ASSIGNMENTS AND TESTS RETURNED PROMPTLY	1	0	1	0	7	9	4.3
5 STUDENT FREEDOM OF EXPRESSION	1	0	0	1	7	9	4.4
6 COURSE OF VALUE TO DATE	1	0	1	0	7	9	4.3
	Vry Unsat	Unsat	Satisfact	Very Good	Excellent		
7 OVERALL INSTRUCTOR RATING	0	0	1	1	7	9	4.7
8 OVERALL COURSE RATING	0	0	1	1	7	9	4.7
	Excessive	High	Average	Light	Insuffic		
9 STUDENT RATING OF COURSE WORKLOAD	0	0	8	0	1	9	
	Less 2.00	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00		
10 OVERALL UT GRADE POINT AVERAGE	0	0	0	1	7	8	
	A	B	C	D	F		
11 PROBABLE COURSE GRADE	5	3	0	0	0	8	

For the computation of averages, values were assigned on a 5-point scale so that the most favorable response was assigned a value of 5 and the least favorable response was assigned a value of 1.

Scanned: 12/10/2010

Printed: 06/24/2013

Student comments (if available):

*** PROVISIONAL REPORT ***

UNIVERSITY OF TEXAS AT AUSTIN
Gelkin, Mikhail A E E325 16210
8000 Basic

COURSE-INSTRUCTOR SURVEY
ELECTROMAGNETIC ENGINEERING

Spring 2010 DEPARTMENT COPY
Enrollment = 21
Surveys Returned = 12

	NUMBER CHOOSING EACH RESPONSE					NO. REPLIES THIS ITEM	AVG.
	Str Disag	Disagree	Neutral	Agree	Str Agree		
1 COURSE WELL-ORGANIZED	0	0	1	5	6	12	4.4
2 COMMUNICATED INFORMATION EFFECTIVELY	0	2	3	6	1	12	3.5
3 SHOWED INTEREST IN STUDENT PROGRESS	0	0	3	9	0	12	3.8
4 ASSIGNMENTS AND TESTS RETURNED PROMPTLY	0	0	1	5	6	12	4.4
5 STUDENT FREEDOM OF EXPRESSION	0	0	2	6	4	12	4.2
6 COURSE OF VALUE TO DATE	0	3	1	6	2	12	3.6
	Vry Unsat	Unsat	Satisfact	Very Good	Excellent		
7 OVERALL INSTRUCTOR RATING	0	0	4	5	1	10	3.7
8 OVERALL COURSE RATING	0	2	4	3	1	10	3.3
	Excessive	High	Average	Light	Insuffic		
9 STUDENT RATING OF COURSE WORKLOAD	0	4	6	1	0	11	
	Less 2.00	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00		
10 OVERALL UT GRADE POINT AVERAGE	0	0	2	5	4	11	
	A	B	C	D	F		
11 PROBABLE COURSE GRADE	3	3	5	0	0	11	

For the computation of averages, values were assigned on a 5-point scale so that the most favorable response was assigned a value of 5 and the least favorable response was assigned a value of 1.

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*** PROVISIONAL REPORT ***

UNIVERSITY OF TEXAS AT AUSTIN — COURSE-INSTRUCTOR SURVEY — Fall 2009 DEPARTMENT COPY
Belkin, Mikhail A E E383V 17270 — NONLINEAR OPTICS — Enrollment = 18
B000 Basic — Surveys Returned = 15

	NUMBER CHOOSING EACH RESPONSE					NO. REPLIES THIS ITEM	AVG.
	Str Disag	Disagree	Neutral	Agree	Str Agree		
1 COURSE WELL-ORGANIZED	0	0	0	13	2	15	4.1
2 COMMUNICATED INFORMATION EFFECTIVELY	0	0	1	10	4	15	4.2
3 SHOWED INTEREST IN STUDENT PROGRESS	0	0	2	8	5	15	4.2
4 ASSIGNMENTS AND TESTS RETURNED PROMPTLY	0	0	0	11	4	15	4.3
5 STUDENT FREEDOM OF EXPRESSION	0	0	0	8	7	15	4.5
6 COURSE OF VALUE TO DATE	0	0	0	10	5	15	4.3
	Vry Unsat	Unsat	Satisfact	Very Good	Excellent		
7 OVERALL INSTRUCTOR RATING	0	0	2	10	3	15	4.1
8 OVERALL COURSE RATING	0	0	5	9	1	15	3.7
	Excessive	High	Average	Light	Insuffic		
9 STUDENT RATING OF COURSE WORKLOAD	1	0	13	1	0	15	
	Less 2.00	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00		
10 OVERALL UT GRADE POINT AVERAGE	0	0	0	3	11	14	
	A	B	C	D	F		
11 PROBABLE COURSE GRADE	9	6	0	0	0	15	

For the computation of averages, values were assigned on a 5-point scale so that the most favorable response was assigned a value of 5 and the least favorable response was assigned a value of 1.

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*** PROVISIONAL REPORT ***

UNIVERSITY OF TEXAS AT AUSTIN — COURSE-INSTRUCTOR SURVEY — Spring 2009 DEPARTMENT COPY
Belkin, Mikhail A — E E396V — 16900 — NANOSTRUCTURED OPTOELECTRONICS — Enrollment = 4
8000 Basic — Surveys Returned = 3

	NUMBER CHOOSING EACH RESPONSE					NO. REPLIES THIS ITEM	AVG.
	Str Disag	Disagree	Neutral	Agree	Str Agree		
1 COURSE WELL-ORGANIZED	0	0	0	2	1	3	4.3
2 COMMUNICATED INFORMATION EFFECTIVELY	0	0	0	1	2	3	4.7
3 SHOWED INTEREST IN STUDENT PROGRESS	0	0	0	1	2	3	4.7
4 ASSIGNMENTS AND TESTS RETURNED PROMPTLY	0	0	0	2	1	3	4.3
5 STUDENT FREEDOM OF EXPRESSION	0	0	0	0	3	3	5.0
6 COURSE OF VALUE TO DATE	0	0	0	1	2	3	4.7
	Vry Unsat	Unsat	Satisfact	Very Good	Excellent		
7 OVERALL INSTRUCTOR RATING	0	0	0	2	1	3	4.3
8 OVERALL COURSE RATING	0	0	1	1	1	3	4.0
	Excessive	High	Average	Light	Insuffic		
9 STUDENT RATING OF COURSE WORKLOAD	0	0	3	0	0	3	
	Less 2.00	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00		
10 OVERALL UT GRADE POINT AVERAGE	0	0	0	1	1	2	
	A	B	C	D	F		
11 PROBABLE COURSE GRADE	2	0	0	0	0	2	

For the computation of averages, values were assigned on a 5-point scale so that the most favorable response was assigned a value of 5 and the least favorable response was assigned a value of 1.

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THE UNIVERSITY OF TEXAS AT AUSTIN
OFFICE OF GRADUATE STUDIES
COMMITTEE REPORT, MASTERS AND DOCTORAL
FOR BELKIN, MIKHAIL A

NAME	EID	LAST SEM	COMM POSITION	MAST OR DOCT	DEGREE	FIELD	YYS	2ND DEGREE	FIELD	YYS
BENNETT, AGATHA KAREN	akb2382	136	CO-CHAIR	M	M.A.	SCIENCE EDUCA	20136			
CHEN, PAI-YEN	cp23985	136	MEMBER	D	PH.D.	ELECTRICAL AN	20136			
COVEY, JOHN LUTHER	jlc4692	139	MEMBER	D						
CROOK, ADAM MICHAEL	amc3366	122	MEMBER	D	PH.D.	ELECTRICAL AN	20122			
HOSSEINI, AMIR	ah27988	116	MEMBER	D	PH.D.	ELECTRICAL AN	20116			
JANG, MIN	mj4367	129	CHAIR	D	PH.D.	ELECTRICAL AN	20129			
JUNG, JOO-YUN	jj2442	109	MEMBER	D	PH.D.	ELECTRICAL AN	20109			
KIM, HOO	kh24579	132	MEMBER	D						
LEE, JONGWON	jl37847	139	CHAIR	M	M.S.E.	ELECTRICAL AN	20119			
LI, JINGSI	jl42779	139	MEMBER	D						
NAIR, HARI PARAMESWARAN	hpn87	132	MEMBER	D	PH.D.	ELECTRICAL AN	20132			
VIJAYRAGHAVAN, KARUN	kv3474	139	CHAIR	D						
YIN, BIWEI	by946	136	MEMBER	D	PH.D.	ELECTRICAL AN	20136			
ZHAO, YANG	yz3376	132	MEMBER	D	PH.D.	ELECTRICAL AN	20132			

Postdoctoral Scholars Supervised

Mikhail A. Belkin
Department of Electrical and Computer Engineering, The University of Texas at Austin
mbelkin@ece.utexas.edu

This document identifies the postdoctoral scholars I have supervised in rank at the University of Texas at Austin.

• Dr. David Austin, Ph.D. from the Physics and Astronomy Department, University of Sheffield, UK, 2010. Appointment in my group: 5/18/2010-10/31/2011

• Dr. Seungyong Jun, Ph.D. from the Electrical and Computer Engineering Department, State University of New York at Stony Brook, 2012. Appointment in my group: 2/1/2013-present.

Budget Council Assessment of Research, Publications & Other Evidence of Scholarship/Creativity

Mikhail Belkin

Summary

In his time at UT, Mikhail Belkin has established himself as a leading figure in the field of terahertz photonics based on work that is already recognized as having the potential to revolutionize terahertz source technology. Specifically, he has combined his insight into nonlinear optics with highly sophisticated design and experimental work on semiconductor heterostructures to demonstrate a new approach for room-temperature, tunable, compact terahertz lasers. Furthermore, he has exploited his expertise in terahertz and mid-infrared sources to develop new approaches for high-resolution molecular spectroscopy, with performance comparable to, or better than, that of any competing techniques. These new approaches can potentially lead to single-molecule sensitivity. This combination of both high-impact device engineering and fundamental scientific advances is very unusual. It reflects Professor Belkin's deep understanding of optical and condensed matter physics and his ability to apply that understanding to solid-state device engineering. He has a very strong publication record, with 29 journal articles published in rank and 56 in his career. He also has a strong record in raising extramural funds to support his research. Professor Belkin's research accomplishments, both in quantity, and more importantly in depth, creativity, and impact, certainly exceed the standard for promotion to Associate Professor.

Research Area and Contributions

Professor Belkin's current research is broadly concerned with the generation, physics, and application of mid-infrared and terahertz electromagnetic radiation, corresponding to wavelengths of ~3-1000μm (energies of approximately 1-400meV). Interest in this area has grown tremendously in the past several years, driven by potential applications in molecular spectroscopy, imaging, and communications combined with a dearth of high-quality sources for radiation in the terahertz frequency range (~100-1000μm wavelength). Professor Belkin brings to his research a unique combination of attributes: deep fundamental understanding of optical physics, particularly nonlinear optics; outstanding experimental capability and daring; and a very practical focus on the issues necessary to reach a particular engineering or scientific goal. As described below, his research at UT has extended from development of new room-temperature terahertz laser sources to ultrahigh-resolution molecular spectroscopy that exploits key properties of mid-infrared laser technology on which he is working.

Among his primary research contributions in rank are the following:

1. **Room-temperature, compact terahertz lasers.** Room-temperature terahertz-frequency signal sources have long been sought, but are extremely challenging to develop for the following reasons: (1) purely electronic approaches, which dominate at lower frequencies, suffer from severely reduced efficiency and power output as operating frequency is increased to the terahertz range, (2) optical approaches, which dominate at higher frequencies, have required cryogenic operating temperatures and suffer from reduced power output as terahertz frequencies are approached. In research culminating in two key publications in 2013, Belkin reported the first demonstration of a room-temperature, terahertz-frequency laser [A.5] and, shortly thereafter, tunable terahertz-frequency lasing with record power output at room temperature [A.4]. These results built upon earlier work by Belkin in which he developed a terahertz-frequency quantum cascade laser source in which infrared signals were mixed via an engineered semiconductor quantum-well giant optical nonlinearity to produce terahertz radiation, but only at low temperature [A.40]. In [A.4] and [A.5], Belkin combined this idea with extraction of Cerenkov radiation via re-design of the quantum cascade laser cavity to achieve room-temperature terahertz-frequency lasing. He continues

developing this technology very rapidly to achieve further increases in efficiency and output power. Belkin's results have already inspired research by others adopting his approach [e.g., Q. Y. Lu, M. Razeghi et al, Appl. Phys. Lett. 103, 011101 (2013)]. It is very likely that his breakthrough will lead to substantial new advances in both the development of room-temperature, compact laser sources, and their application in molecular spectroscopy, imaging, communications, astronomy, and other areas.

2. **Sub-wavelength resolved mid-infrared molecular spectroscopy.** Belkin has leveraged his expertise in mid-infrared quantum-cascade lasers to demonstrate a very exciting and innovative approach to mid-infrared molecular spectroscopy that circumvents the traditional diffraction limit in spatial resolution and provides extremely high sensitivity and spatial resolution of 30-50nm (at wavelengths of ~7000-9000nm). Specifically, Belkin was able to detect thermal expansion of molecular layers associated with heating by a mid-infrared quantum cascade laser using an atomic force microscope (AFM), and to amplify the AFM response by modulating the laser excitation at the vibrational resonance frequency of the AFM cantilever probe [A.12]. In this work, the spatial resolution achieved was ~50nm, limited by thermal diffusion in the sample. Subsequently, Belkin implemented this approach using a gold-coated AFM cantilever probe for which the spatial resolution is limited by the dimensions of the probe tip (this occurs because the incident optical power becomes strongly focused in the vicinity of the gold-coated probe tip). In this work, currently under review, spatial resolution of ~30nm and sensitivity to ~100 molecules has been achieved. This is comparable to, or better than, results for competing near-field optical spectroscopy techniques, and the potential exists for spectroscopy at the single-molecule level. Furthermore, Belkin's approach can be implemented using relatively straightforward experimental setups and therefore it could have a widespread impact in the field of molecular spectroscopy.

In addition to these advances, Belkin has made very substantial contributions in plasmonic structures for optical filters [A.13] and compact circular polarizers [A.8], and in infrared quantum cascade lasers for free-space optical communications applications [A.5, A.6]. His research is well recognized and very highly regarded in the international photonics and optoelectronics research communities, and several external referees attest to the quality and impact of his work. D. Botez (University of Wisconsin-Madison) writes that Belkin's terahertz quantum cascade laser work "may well turn out to be revolutionary.... resulting in the practical THz devices that many researchers have worked on or dreamed of for over 12 years now." Similarly, J. Faist (ETH) writes that Belkin's work on room-temperature terahertz quantum cascade lasers has "the potential to revolutionize the field of Terahertz" and that he considers Belkin to be "the strongest scientist in the field in his age group." M. Scully (Texas A&M University and Princeton University) writes that Belkin's group is "the leading group in the area of terahertz quantum cascade laser sources and terahertz photonics in general." And J. Coleman (U of Illinois at Urbana-Champaign) writes that Belkin is "on a clear vector to equaling the career of Gmachl [currently Eugene Higgins Professor of Electrical Engineering at Princeton] and potentially approaching that of Capasso [currently Robert L. Wallace Professor of Applied Physics at Harvard, and member of both NAS and NAE].... anything you can do to keep him happy there is a wise investment."

Publications and Impact

Professor Belkin has an extremely strong publication record, with 29 journal articles published in rank (as of 1 August 2013) and 56 such articles in his career. He is first and/or corresponding author on 10 journal articles in rank, covering a wide range of topics as described above. His published research is distinguished by careful, detailed experimentation, deep and insightful analysis, and emphasis on very significant and substantive advances. His journal publications in rank include 2 in Nature Communications, 10 in Applied Physics Letters, 4 in Optics Express, and 1 in Optics Letters. As of 1 August 2013, his publications have been cited 1265 times (ISI Web of Science) and he has an h-index of 22. These are outstanding citation counts for a researcher in Belkin's field and at his career stage.

Research Funding

Professor Belkin has a strong record in garnering extramural funds in support of his research. He has received funding for 12 projects to date, and was Principal Investigator for 8 of these. His share of funding for these 12 projects is $2.48M. He has received the DARPA Young Faculty Award (2012), NSF CAREER Award (2012), Norman Hackerman Advanced Research Program Award for Early Career Investigators (2012), and the AFOSR Young Investigator Award (2009).

Peer Comparisons

Professor Belkin has an outstanding record of research accomplishment, recognition, and citation impact relative to other researchers of his seniority in mid-infrared and terahertz photonics. The chart below shows a summary of awards/honors, current position and institution, year of Ph.D., year of promotion to tenure, publications, citations, and h-index for several leading researchers in these areas who received their Ph.D. degrees during 1998-2004 and were promoted to Associate Professor at their institutions during 2008-11. Belkin received his Ph.D. in 2004 and is proposed for promotion effective 2014. As shown in the chart, Belkin compares very well with these other researchers in awards and honors received, and has had comparable citation impact (h-index) although the other researchers listed were promoted to Associate Professor two to five years ago. In interpreting the table below, it should be noted that N. Fang's citation record is somewhat unusual in that it includes three extremely highly cited papers from his work as a graduate student, which together have been cited >2200 times.

Name (field)	Institution	Awards/Honors[#]	Promoted to tenure	Title	Ph.D	Pubs[*]	Cit[*]	h[*]
Mikhail Belkin (mid-IR/THz photonics)	UT	CAREER, AFOSR, DARPA	-	Assistant	2004	56	1265	22
Nicholas X. Fang (metamaterials, plasmonics)	MIT	CAREER, TR35, SME	2011	Associate	2004	72	4250	26
Jamie Phillips (mid-IR optoelectronics)	U. of Michigan	CAREER, DARPA	2008	Associate	1998	99	2004	22
Farhan Rana (optoelectronics)	Cornell	CAREER, DARPA	2009	Associate	2004	64	1063	17

[#] CAREER=NSF CAREER award; AFOSR=AFOSR Young Investigator award; DARPA=DARPA Young Faculty award; TR35=Technology Review Innovator Under 35; SME=Society of Manufacturing Engineers Young Manufacturing Engineer Award.

[*] Publication and citation data as of August 2013, from ISI Web of Science.

Conclusion

Professor Belkin is an outstanding and accomplished researcher who has made important advances in the development of terahertz laser sources and in high-resolution molecular spectroscopy while in rank at UT. His work is very creative and reflects both deep physical understanding and the ability to engineer practical devices. He has become an acknowledged leader in the field of terahertz photonics, with multiple external reviewers attesting to both the impact his work has already had, and the potential of his breakthroughs to "revolutionize" his field.

Basis for Evaluation

This Budget Council assessment of Dr. Belkin's research is based on a thorough evaluation of the materials assembled by the candidate for promotion to associate professor, in-depth knowledge of the candidate's activities, publications, and research area, and a peer group comparison with researchers at leading institutions. In addition, I have incorporated a few pertinent comments from the very strong set of reference letters regarding specific aspects of his research track record.

Prepared by Electrical and Computer Engineering Budget Council member

Edward T. Yu 3 August 2013

M.A. Belkin – Five Most Significant Publications While in Rank

This document identifies the five most significant peer-reviewed publications produced while in rank at UT Austin.

1. K. Vijayraghavan, Y. Jiang, M. Jang, A. Jiang, K. Choutagunta, A. Vizbaras, F. Demmerle, G. Boehm, M. C. Amann, and M. A. Belkin "Broadly-tunable terahertz generation in mid-infrared quantum cascade lasers," *Nature Comm.* **4,** 2021 (2013). http://dx.doi.org/10.1038/ncomms3021
2. K. Vijayraghavan, R.W. Adams, A. Vizbaras, M. Jang, C. Grasse, G. Boehm, M. C. Amann, and M.A. Belkin "Terahertz Sources Based on Čerenkov Difference-Frequency Generation in Quantum Cascade Lasers," *Appl. Phys. Lett.* **100,** 251104 (2012). http://dx.doi.org/10.1063/1.4729042
3. Y. Zhao, M.A. Belkin, and A. Alu, "Twisted optical metamaterials for planarized, ultrathin, broadband circular polarizers," *Nature Comm.* **3,** 870 (2012). http://dx.doi.org/10.1038/ncomms1877
4. F. Lu and M.A. Belkin, "Infrared absorption nano-spectroscopy using sample photoexpansion induced by tunable quantum cascade lasers," *Optics Express* **19,** 19942-19947 (2011). http://dx.doi.org/10.1364/OE.19.019942
5. J. Lee, F. Lu, and M.A. Belkin, "Broadly wavelength tunable bandpass filters based on long-range surface plasmon polaritons," *Opt. Lett.* **36,** 3744-3746 (2011). http://dx.doi.org/10.1364/OL.36.003744

Research Statement

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Summary: I am interested in exploring a broad range of opportunities for novel optoelectronic and optomechanical devices, metamaterials, and photonic systems operating in mid-infrared (mid-IR) and terahertz (THz). This part of electromagnetic spectrum (wavelength range λ=3-1000 μm) is much underdeveloped while hosting numerous applications such as chemical and biological sensing, spectroscopy, imaging, security screening, and free-space communications, to name a few. Additionally, this range is ideal for testing novel concepts for optical metamaterials thanks to low Ohmic loss of metals, relaxed fabrication tolerances, and plasmonic properties of a number of novel low-dimensional materials, such as graphene.

Lab instrumentation: My current laboratory equipment consists of two Fourier-Transform IR spectrometers configured for measurements in both mid-IR and THz, an atomic force microscope (AFM) with optical access to the sample, a grating-tunable high-power pulsed CO_2 laser, a broadly-tunable mid-IR quantum cascade laser (QCL) system, a variety of mid-IR and THz detectors and optical components, and a variety of electronics for QCL operation in pulsed and DC mode, signal amplification, optical detection, and experiential control.

Major accomplishments:

I consider the following two results of my research program at the University of Texas at Austin to have major impact on the current state-of-the-art of mid-IR and THz technology.

1. Our development of the first widely-tunable room-temperature QCL sources of THz radiation that are similar in compactness, operation simplicity, and mass producibility to near IR diode lasers. Our latest devices provide over 120 μW of THz power output at 4 THz at room temperature and can be spectrally tuned in the 1.7-5.3 THz range. (Vijayraghavan *et al.*, *Nature Comm.* **4**, 2021 (2013); the links to the papers here and below are clickable)

2. Our development of the 'molecular force spectroscopy' technique that allows collecting mid-IR spectra of samples as small as monolayer islands with spatial resolution better than 30 nm (λ/300) in ambient conditions. (manuscript is under review, preprint is available at http://users.ece.utexas.edu/~mbelkin/microscopy_preprint.pdf)

The research projects that led to these results as well as our other research projects are described further below.

Visibility, recognition, and funding: I was fortunate to receive a number of young faculty awards to support our research, including AFOSR young investigator research program award (2009), NSF CAREER award (2012), DARPA young faculty award (2012), and Norman Hackerman early career investigator award from the State of Texas (2012). Overall I attracted over $2.4M of research funding (my share) through NSF, DARPA, DOE, AFOSR, ARO, Welch Foundation, and the state of Texas grants. I have presented 20 invited talks on results produced at the University of Texas at Austin at major research conferences, including CLEO, CLEO-Europe, Photonics West, and the Materials Research Society Meeting. My CV provides further details on publications, conference talks, and funding.

Research projects at the University of Texas at Austin:

1. ***Mass-producible room-temperature THz sources***

The project aims to produce room-temperature sources in 1-5 THz that are electrically-pumped, broadly-tunable, compact, and suitable for a production in large quantities.

THz QCLs are a promising technology for this spectral range; however, their maximum operating temperature in pulsed mode is still below 200° K. In collaboration with Christian Jirauschek's group at the Technical University of Munich, we have theoretically investigated approaches to improve the operating temperature of THz QCLs by employing diagonal laser transitions (Matyas *et al., Appl. Phys. Lett.* **96,** 201110 (2010)) and by designing active regions using barriers with variable heights (Matyas *et al., J. Appl. Phys.* **111,** 103106 (2012)). Only minor improvements were expected theoretically. In collaboration with Edmund Linfield's group (University of Leeds, provided QCL structure growth) and Federico Capasso's group we experimentally investigated the performance of THz QCLs based on double-phonon depopulation scheme that aimed to prevent thermal backfilling of the lower laser state at high operating temperatures (Adams *et al., Appl. Phys. Lett.* **97,** 131111 (2010)). This work indicated that thermal backfilling is *not* a major factor limiting temperature performance. In collaboration with Edmund Linfield, Raffaele Colombelli, and Federico Capasso's groups we then performed comprehensive experimental investigation of the other possible limiting factors of THz QCL performance (Chassagneux *et al., IEEE Trans. THz Sci. Technol.* **2,** 83 (2012)). This work confirmed that optical phonon scattering of thermal electrons in the upper laser state is the main factor for THz QCL performance degradation with temperature.

The problem of thermal electron scattering in the upper QCL state may potentially be solved using materials with high optical phonon energy (AlGaN), non-polar materials (SiGe), or quantum dots. However, none of these approaches produced operational QCLs so far. As an alternative, we focused on sources based on nonlinear THz generation in mid-IR QCLs.

Free carriers limit the absorption length for THz radiation in mid-IR QCLs to 20-100 μm. One way to circumvent this problem is to 'concentrate' optical nonlinearity near the output facet of the laser. In collaboration with Markus Amann's group (Technical University of Munich, provided QCL structure growth) we investigated the performance of mid-IR QCLs with passive multi-quantum-well sections designed for giant nonlinearity for difference-frequency generation (DFG) and integrated near the output facet (Adams *et al., Appl. Phys. Lett.* **98,** 151114 (2011)). Unfortunately, the lasers only operated at cryogenic temperatures and THz power output was only a few hundreds of nanowatts. Theoretical analysis performed in collaboration with Alexey Belyanin's group (Texas A&M) showed that even in the very best case scenario, due to intensity saturation of intersubband transitions, THz power would be limited to a few hundred microwatts while the laser performance suffers from optical losses in passive nonlinear sections (Cho *et al., Proc. SPIE* **7953,** 79530U, San Francisco, CA (2011)).

We also investigated the possibility of creating a THz intersubband Raman laser. Theoretical analysis, performed in collaboration with Alexey Belyanin's group, demonstrated that THz Raman laser may in principle be possible using giant intersubband nonlinearities, but no Raman lasing was observed experimentally, despite our best efforts. (Vijaraghavan *et al., Proceedings of IRMMW-THz Conference*, pp. 590-591 (2011))

The breakthrough came when we realized that the InGaAs/AlInAs/InP materials system used for state-of-the-art mid-IR QCLs is ideal for implementing QCL sources based on Cherenkov DFG scheme in which optical nonlinearity with population inversion may be integrated into the whole QCL active region and THz radiation is extracted into an undoped InP substrate along the whole length of the laser waveguide (Vijayraghavan *et al.*, *Appl. Phys. Lett.* **100,** 251104 (2012)). Further optimization of the active region and waveguide design in these devices resulted in room-temperature QCL sources providing record 120 μW of peak power output at 4 THz and tunable in the1.7-5.3 THz range (Vijayraghavan *et al.*, *Nature Comm.* **4**, 2021 (2013)).

Future work will focus on improving power output of Cherenkov DFG-QCLs by optimization of the active region design and the waveguide structure, demonstrating continuous-wave operation at room-temperature, performing THz linewidth measurements, and development of compact room-temperature THz systems for heterodyne-based detection, imaging, spectroscopy, sub-wavelength resolution microscopy, and communications, to name a few examples.

2. *Sub-wavelength resolution microscopy*

Mid-IR absorption spectroscopy is widely used for chemical identification and quantitative analysis in ambient conditions. One way to achieve mid-IR spectroscopy on nanoscale is to observe deflection of the AFM cantilever induced by rapid sample thermal expansion due to light absorption. This approach previously required high-fluence optical pulses from free-electron lasers or high-power optical parametric oscillators (OPO) and also relatively thick samples (approximately 50-nm-thick or thicker) to produce detectable cantilever deflection signal.

We started this project questioning whether mid-IR QCLs can be used to perform similar spectroscopic measurements. The power output from a QCL is orders of magnitude smaller than that available from free-electron lasers or high-power OPOs; however, the repetition frequency of light pulses from QCLs can be easily controlled by current generator to match the mechanical resonance frequency of the AFM cantilever. In this case the cantilever deflection amplitude is enhanced by the quality factor (Q-factor) of the AFM cantilever which can be as high as $5x10^3$ in air. We demonstrated that this approach can be used to perform QCL-based mid-IR microscopy of samples as thin as 50 nm with better than 50 nm spatial resolution (Lu and Belkin, *Optics Express* **19,** 19942 (2011)). We then realized that mid-IR intensity enhancement by optical antennas or metalized AFM tips may be used to boost sensitivity and also the spatial resolution of the photoexpansion microscopy, with the spatial resolution now determined by the dimensions of the 'hot spot,' rather than by thermal diffusion length in the case of previous experiments. Using tip-enhancement of light intensity, we achieved mid-IR spectroscopy of molecular monolayer islands with better than 30 nm spatial resolution. We estimate the current sensitivity of our setup to be below 100 molecules which makes it one of the most sensitive *in situ* mid-IR spectroscopic techniques with sensitivity comparable to, or higher than, that of the best mid-IR scattering near-field optical microscopy (manuscript under review, preprint is available at http://users.ece.utexas.edu/~mbelkin/microscopy_preprint.pdf).

Future work includes demonstrating mid-IR spectroscopy of a single molecule in ambient conditions (which has not been achieved by any means so far), extending the technique to THz spectral range using our new THz QCL sources, and enabling operation in water, to name a few examples.

3. *Plasmonic devices and metamaterials*

I see great potential for development of plasmonic devices and optical metamaterials for operation in mid-IR and THz spectral ranges owing to low Ohmic loss of metals in mid-IR and THz, relaxed fabrication tolerances, and plasmonic properties of low-dimensional materials, such as graphene. Our published results in this area include demonstration of broadly-tunable optical filters based on the unique properties of long-range surface plasmon polaritons (Lee *et al., Opt. Lett.* **36,** 3744 (2011)) in which a 0.004 variation in the refractive index of the dielectric medium translates into 210 nm of bandpass tuning at telecom wavelengths. These filters may be monolithically integrated with laser sources to produce widely-tunable output or used for spectroscopic applications. In collaboration with Andrea Alu's group in my department, we also developed broadband plasmonic circular polarizers based on multi-layer planar nano-inclusions (Zhao *et al., Nature Comm.* **3,** 870 (2012)).

These results were all demonstrated in near-IR owing to availability of suitable light sources and optical components at the time of experients. We are now working to extend these concepts to longer wavelengths for a variety of exciting applications in the mid-IR and THz spectral range, for which convenient sources, such as QCLs, are available, but compact broadly-tunable optical filters and advanced optical elements for polarization control such as broadband achromatic wave plates or broadband circular polarizers are currently unavailable.

4. *Quantum cascade lasers for FM free-space optical links*

Due to the reduction of the Rayleigh scattering, $\lambda = 8–12\mu m$ QCLs are uniquely suited for long-range free-space optical communications. It is well known that frequency modulation (FM) data links can have orders of magnitude higher signal-to-noise ratio compared to the amplitude-modulation (AM) systems. A successful development of QCL-based free-space optical FM links would allow the creation of very-long-range all-weather free-space networks with very large bandwidth. However, only AM data links have been demonstrated with QCLs so far.

In collaboration with Gregory Belenky's group at the State University of New York at Stony Brook, we have recently started a project to develop mid-IR QCLs with fast frequency modulation and to demonstrate the first mid-IR optical FM links. Our latest results include demonstration of a three-terminal QCL with fast electrical control of the emission frequency (Jang *et al., IEEE J. of Quantum Electron.* **49,** 60 (2013)) and demonstration of fast optical control of the emission frequency in mid-IR QCLs (Suchalkin *et al., Appl. Phys. Lett.* **102,** 011125 (2013)).

5. *Short-wavelength quantum cascade lasers with internal frequency doubling*

We also investigated ways to extend the spectral range of InGaAs/AlInAs mid-IR QCLs to shorter wavelength using intracavity quasi-phase-matched second harmonic generation. This work was done in collaboration with Markus Amann's group at the Technical University of Munich. Devices operating at room temperature at wavelengths 3.6 μm (Jang *et al., Appl. Phys. Lett.* **97,** 141103 (2010)), 2.95 μm (Jang *et al., Electron. Lett.* **47,** 667 (2011)), and 2.7 μm (Vizbaras *et al., IEEE J. Quantum Electron.* **47,** 691 (2011)) were demonstrated. However, recent progress of highly-strained mid-IR QCLs and Sb-based diode lasers and type-II cascade lasers makes QCL sources based on frequency-doubling less competitive.

Research Summary and List of External Funding

Table 1. Research Summary

Metric	Value
Peer-Reviewed Journal Publications in Rank	28
Corresponding Author on Peer-Reviewed Publications in Rank	10
Peer Reviewed Conference Proceedings Publications in Rank	37
Total Citations of all Publications (ISI/Google Scholar)	1231 (ISI) / 1756 (Google)
h-index (ISI/Google Scholar)	21 (ISI) / 25 (Google)
Research Funding Raised ($) (candidate share)	$2,481,305
Total Grants/Contracts Received	12
PI on Grants/Contracts Received	8

Table 2. Grants and Contracts Awarded while in Rank

Co-Investigators	Title	Agency	Project Total/	Candidate Share	Grant Period
None	"Mid-infrared photoacoustic spectroscopy with nanometer resolution using quantum cascade lasers"	Welch Foundation	$150,000	$150,000	6/1/09 – 5/31/12
Co-PI Prof. Alexey Belyanin Physics Dept., Texas A&M Univ.	"COLLABORATIVE RESEARCH: Room-temperature terahertz semiconductor Raman lasers"	National Science Foundation	$414,987	$324,987	9/1/09 – 8/31/13
None	"Tunable Quantum Electronic Metamaterials for Mid-Infrared"	Air Force Office of Scientific Research	$359,178	$359,178	4/1/10 – 3/31/13
Co-PI Prof. Alexey Belyanin, Physics Dept., Texas A&M Univ.	"Room-temperature electrically-pumped semiconductor sources of THz radiation"	Texas Higher Education Coordinating Board	$192,381	$132,381	7/1/10 – 8/31/13
PI Prof. Gregory Belenky, SUNY at Stony Brook	"COLLABORATIVE: Ultra-fast tunable quantum cascade lasers"	National Science Foundation	$454,949	$224,759	9/15/10 – 8/31/14
None	"CAREER: Terahertz semiconductor laser sources for operation above cryogenic temperatures"	National Science Foundation	$400,000	$400,000	5/1/12 – 4/30/17
PI Dr. Craig Prater, Anasys Instruments, Santa Barbara, CA	"Resonance-Enhanced Infrared Nanospectroscopy (REINS) based on Atomic Force Microscopy and Quantum Cascade Lasers"	Department of Energy (Phase I STTR)	$150,000	$90,000	2/1/12 – 10/31/12
None	"Plasmonic-enhanced nanoscale mid-infrared microscopy with monolayer sensitivity"	Welch Foundation	$120,000	$120,000	6/1/12 – 5/31/14
None	"Short-wavelength quantum cascade lasers with internal frequency doubling"	Texas Higher Education Coordinating Board	$80,000	$80,000	7/1/12 – 8/31/14
PI Dr. Swapnajit Chakravarty, Omega Optics, Austin, TX	"Monolithic Photonic Crystal On-Chip Spectrometer for Laser Absorption Spectroscopy"	Army Research Office (Phase II SBIR)	$780,000	$150,000	8/27/12 –5/02/14
None	"Room-Temperature High-Power Terahertz Semiconductor Laser Sources"	Defense Advanced Research Projects Agency	$300,000	$300,000	8/13/12 – 8/12/14
PI Dr. Craig Prater, Anasys Instruments, Santa Barbara, CA	"Resonance-Enhanced Infrared Nanospectroscopy (REINS) based on Atomic Force Microscopy and Quantum Cascade Lasers"	Department of Energy (Phase II STTR)	$500,000	$150,000	4/22/13 – 4/21/14
TOTAL			$3,901,495	$2,481,305	

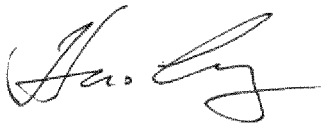
Budget Council Assessment of Academic Advising, Counseling and Other Student Services
Promotion Candidate: Mikhail A. Belkin

This statement provides an assessment of the academic advising, counseling and student service activities of Dr. Mikhail Belkin on behalf of the Budget Council. This assessment is made based on a review of materials in Dr. Belkin's tenure promotion dossier and knowledge of his advising activities during his tenure as an assistant professor.

Dr. Belkin has been actively involved with students at both undergraduate and graduate levels in advisory and counseling capacities. At the undergraduate level, he serves as a faculty advisor to approximately 15 students per year, as is the norm in our department. In this role, he advises students on course selection in the nanoelectronics and nanotechnology concentration area, and discusses career and graduate school options. To further introduce students to his area, he regularly participates in the department's Technical Area Nights. At this event, he presents the various career options in nanoelectronics and nanotechnology and specific course requirements in the area. This activity is important for our undergraduate students, who are often faced with the difficult decision to choose an area of concentration among the many different sub-disciplines in our department. As part of his normal teaching duties, Dr. Belkin has also supervised two senior design teams, one in 2012 with three students and another in 2013 with five students. Each team supervision entails weekly meetings with students to provide project guidance, as well as serving as a liaison with the project's industry sponsor. In addition to academic advising, Dr. Belkin has provided undergraduate research opportunities to three UT undergraduates: Lisa Maria (now at Oracle), Yinzhe Lu (now at IBM), and Karthik Choutagunta; and three undergraduate students from other universities.

At the graduate level, Dr. Belkin has been the Graduate Coordinator for the Solid State Electronics area since 2011. In this capacity, he is in charge of the formation of PhD qualifying exam committees and the administration of the qualifying exam. Dr. Belkin is a very responsible mentor to his own graduate students. He currently advises four PhD students and three MS students. He works closely with each student in all aspects of his or her graduate training, including course selection, qualifying exam, paper writing, oral presentation and internship experience. To date, he has completed the supervision of one PhD dissertation (Min Jang, now at Samsung) and one MS thesis (Robert Adams, now at Baker Hughes). He also participates in the *UTeachEngineering* program by supervising a high school teacher (Kari Bennett) to complete an MA degree in Science, Technology, Engineering and Mathematics Education. This program, funded by NSF and housed in the UT Cockrell School of Engineering, aims to train high school teachers to develop design-based engineering science modules that can be exported, with low implementation cost, to any high school setting. In addition to his undergraduate and graduate advising, Dr. Belkin also supervises one postdoctoral researcher.

In summary, Dr. Belkin has demonstrated commitment to academic advising at both the undergraduate and graduate levels. He has contributed his share of time and energy to student advising and counseling, and positively impacted the lives and careers of our students.



Hao Ling, Ph.D.
Professor
For the Department of Electrical and Computer Engineering Budget Council

Academic Advising and Student Placement

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1. Undergraduate Advising

To date, I have supervised three University of Texas undergraduate researchers working directly in my laboratory: Lisa Maria (now working as SPARC Hardware Engineer at Oracle), Yinzhe Lu (now working as Firmware Engineer at IBM), and Karthik Choutagunta (currently taking an internship at Intel Corporation and planning to continue working as an undergraduate researcher in my laboratory in Fall 2013).

Additionally, I have supervised three summer undergraduate students outside of the University of Texas who worked in my laboratory within the National Science Foundation National Nanotechnology Infrastructure Network Research Experience for Undergraduate program: Ting Chia (Jerry) Chang from the University of California at Berkeley in Summer 2011, Alex Buck from the Rensselaer Polytechnic Institute in Summer 2012, and Priyanka Gaur from Massachusetts Institute of Technology in Summer 2013.

I pair each undergraduate student with a graduate student or a postdoctoral scholar mentor and provide them with a well-defined project that is adapted to match their abilities and interests. Lisa Maria and Yinzhe Lu were focused on developing software and hardware for experimental control of our quantum cascade laser characteristics measurement setup. Karthik Choutagunta developed and deposited mid-infrared anti-reflection coatings for quantum cascade lasers and participated in building a setup for quantum cascade laser tuning. He is a co-author of our 2013 paper in Nature Communications. He has also received the R. W. and Kathleen Lindsey Endowed Presidential Scholarship in Summer 2012 thanks, in part, to his research experience in my laboratory. Alex Buck was developing anti-reflection coatings for terahertz quantum cascade lasers. Jerry Chang and Priyanka Gaur were involved in fabricating and testing various plasmonic metamaterials for operation in mid-infrared and THz spectral range. I wrote a recommendation letter for Jerry Chang's electrical engineering graduate school applications and, thanks in part to his experience in my laboratory, he got multiple admission offers, including that from Stanford which he accepted.

I have supervised a senior design project team consisting of three ECE undergraduates, James Lundberg, Michael Marquez, and Trevor Latson, in the Spring and Summer semesters of 2012. The project was sponsored by Pecan Street, Inc. with the goal of realizing a system for residential power factor correction. I am now supervising another senior design project team consisting of five ECE undergraduates Omar Alatorre, Alan, Lopez, Kevin Nguyen, Robert Payne, and Alfonso Batista. The project that spans the Spring and Fall semesters of 2013 is sponsored by National Instruments Corporation with the goal of realizing a computer-assisted optical tomography system.

I have also helped with orientation for incoming undergraduate students at ECE HKN Tech Area Nights by presenting information about the Solid State area and having discussions to help students select their technical areas of emphasis.

2. Graduate and Post-Graduate Advising

I am currently advising four Ph.D. students with one in candidacy and two more planning to take their qualifying exams in Fall 2013, three M.S. students (all planning to continue on to get their Ph.D. in my group), and one postdoctoral scholar. Additionally, one Ph.D. student, Min Jang, graduated in my group in Fall 2012 and one MS student, Robert Adams, graduated in my group in Spring 2011. Min is now working in Samsung LSI in Korea. Robert is currently working as a Product Development Electrical Engineer in Baker Hughes in Houston, TX.

I spend a large amount of time with each student and postdoc in my group and I monitor their progress closely with weekly meetings and daily quick chats. I provide senior graduate students sufficient freedom and invite independent research explorations. Junior undergraduate students are coupled with senior graduate students and postdocs for training. In many cases, they also learn the experimental techniques from me as I regularly come to the laboratory to observe and perform measurements with my students. Postdoctoral scholars in my group are encouraged to supervise junior graduate students and develop their research projects together. This gives postdoctoral scholars an opportunity to practice supervisions skills and increases their productivity, while graduate students learn new skills from the postdoctoral scholars.

All my graduate students are financially supported by research assistantships, teaching assistantships, or fellowships.

I also participate in the UTeachEngineering Master of Arts in Science, Technology, Engineering, and Mathematics Education as a Master's Thesis summer research supervisor. A high school teacher, Kari Bennett, is performing MS thesis research on anti-reflection coatings in my laboratory in Summer 2013.

Table 1. Summary of Academic Advising

Metric	Value
Student Organizations Advised	1 (HKN)
Undergraduates Supervised	6
PhD Students Completed *	1 (1 sole advisor)
MS Students Completed*	1 (1 sole advisor)
PhD Students in Pipeline (as of 09/2013)*	4 (4 sole advisor)
MS Students in Pipeline (as of 09/2013)*	3 (3 sole advisor)

*count 1 if sole advisor, 0.5 if co-advised

Table 2. List of Completed Graduate Students under My Supervision

Student	Co-Supervisor	Degree	Start	Dissertation/ MS Thesis	Placement
Min Jang	none	PhD	09/2006	12/2012	Samsung LSI, Republic of Korea.
Robert W. Adams	none	MS	09/2008	12/2011	Baker Hughes Corporation, Texas

Budget Council Assessment on Service to the University and to the Nation, State, and Community for Faculty Promotion Candidate Mikhail A. Belkin

This statement on the service to the university and to the nation, state, and community for Assistant Professor Mikhail A. Belkin was prepared by Budget Council Member Professor Gary A. Hallock. The statement was prepared following a review of his annual reports, and an in-depth knowledge of his ECE departmental activities. Professor Belkin has been actively involved in service throughout his career at UT and has made contributions to our department well in excess of that normally expected from faculty of comparable time in rank within the Electrical and Computer Engineering Department.

Service to the University

Dr. Belkin has provided significant service to the department and the university. He is Coordinator for the Solid-State Electronics graduate program, and in addition, actively participates in the Plasma and Quantum Electronics graduate program. An important aspect of this work is the selection and active recruitment of new graduate students. To recruit the best graduate students to our program requires a large time commitment and effort, including application reviews, laboratory research presentations to prospective students, dinners, and writing fellowship nominations and multi-year research assistantships. Dr. Belkin has also been active in promoting our program to top UT undergraduates, including presentations and discussions at the ECE HKN Tech Area Nights.

The capabilities of the Microelectronics Research Center (MRC) have been greatly expanded by Dr. Belkin. He has led the acquisition of at least three major tools for the nanofabrication user facility. This equipment has opened up major new opportunities for engineering research at UT. For example, the III-V ICP RIE tool has enabled chlorine compounds-based deep etching of III-V semiconductors and other materials, which is crucial for high quality processing of optoelectronic devices such as diode and quantum cascade lasers. Many research groups are now taking advantage of this new capability, including Bank, Belkin, Chen, Cheng, and Yu. Another major tool that Dr. Belkin has brought to MRC is an Applied Microengineering Aligner-Wafer Bonder tool. This tool has brought the capability of performing large area wafer bonding, including metal-metal thermocompression bonding and dielectric anodic bonding. Examples of this system usage in MRC include fabrication of solar cells (Yu group), optical metamaterials (Belkin group), terahertz quantum cascade lasers (Belkin group), and electro-optic modulators (Chen group).

Dr. Belkin has been active in graduate course development. He has developed two new courses on Nanostructured Optoelectronics and Nonlinear Optics. The Nonlinear Optics course has filled a substantial gap in the optics curriculum in the ECE department. Nonlinear optical effects are ubiquitous in modern optical and optoelectronic devices and systems, and are driving the development of ultra-fast all

optical networks. A deep understanding of nonlinear optical effects is critically important for any optical engineer, and our program is greatly enhanced with these courses.

Service to the Nation, State, and Community

Dr. Belkin's service to the nation, state, and community has been exceptional. He is currently co-chair of the 12th International Conference on Intersubband Transitions in Quantum Wells, to be held in September 2013. ITQW is the leading international conference on the physics of intersubband transitions and devices based on this effect. Dr. Belkin has served or is serving on many other conference program committees, including CLEO, the most highly regarded optoelectronics conference.

Dr. Belkin revived the Photonics Society Texas Chapter, which was about to be closed in 2010. He has organized two technical meetings per year, with distinguished speakers presenting their photonics research. These meetings are open to UT faculty and students, as well as IEEE Photonics Society members.

Another area of national service where Dr. Belkin excels is in manuscript peer review. He has provided over 50 peer reviews for manuscripts submitted to a variety of journals, from physics to electrical engineering to chemistry. This strongly attests to his wide breadth of technical knowledge and reputation. He has also provided 12 reviews of papers submitted to the Nature family journals, which are one of the most prestigious and selective family of journals.

Identifying fraud and technical flaws in publications, especially in high impact publications, is another service that Dr. Belkin has provided. He was part of a team that identified significant technical flaws in a report published in the Nature Photonics journal, the most selective journal in optics and photonics. The errors that he uncovered were much more than simple measurement errors; the whole concept was wrong as well as the claimed device improvement. This led to the paper's retraction in March 2013.

Dr. Belkin is very active in community outreach. He supervises students from the NSF undergraduate research experience program. He is also working to improve STEM education. He has served as an MS thesis supervisor for school teachers working on their Master of Arts in STEM Education. This program is dedicated to developing leaders in the emerging field of secondary engineering education. Some of these teachers have done experimental work in his lab for their thesis.

In summary, in the area of service to the university, and to the nation, state, and community, Professor Belkin's performance has been outstanding. He is a rising star and has consistently and significantly exceeded our department's expectations.

Service to the University and to the Nation, State and Community

Mikhail A. Belkin
Department of Electrical and Computer Engineering, The University of Texas at Austin
mbelkin@ece.utexas.edu

In addition to teaching and research, I have been involved in a number of service activities to the University, Nation, State and Community. Details are summarized in my CV and are listed below.

1. **Service to The University of Texas at Austin**

I am serving as the Coordinator for the Solid-State Electronics graduate program track in the ECE Department. I have also helped orientation for incoming undergraduate students presenting information about the Solid State area at the ECE HKN Tech Area Nights and having discussions to help students select their technical areas of emphasis.

I am a member of two department committees: the ECE Transition Committee that manages the ECE department's transition to a new building and the ECE Seminars Committee that identifies and invites distinguished speakers for the ECE Colloquia and ECE Distinguished Lecture series.

Additionally, I have made significant contributions to improving the infrastructure of the nanofabrication user facility in the Microelectronics Research Center by leading the acquisition of three major research equipment tools. More specifically, I have initiated discussion, determined key parameters/options, negotiated price, and led the purchase of Oxford Instruments Inductively-Coupled Plasma Reactive Ion Etching system for III-V materials (purchased for approximately $450,000), Applied Microengineering Aligner-Wafer Bonder tool (purchased for approximately $150,000), and the Kulicke and Soffa Industries 4500 Series Manual Wire Bonder tool (purchased for approximately $25,000).

Finally, I have developed two new graduate-level courses on Nanostructured Optoelectronics and Nonlinear Optics for the ECE Department.

2. **Service to the Nation, State, and Community**

I am currently serving as a co-chair of the 12th International Conference on Intersubband Transitions in Quantum Wells to be held in Bolton Landing, NY, in September 2013. I have also served or I am serving on a number of conference program committees for the major conferences in my area. In particular, I am currently serving as a member of the Semiconductor Laser program committee of CLEO conference, the most highly regarded optoelectronics conference. Previously, I have served as a program committee member for the 35th International Conference on Infrared, Millimeter and Terahertz Waves (2011), the 11th International Conference on Intersubband Transitions in Quantum Wells (2011), the IEEE Photonics Society topical meeting "Advances in Terahertz Devices and Applications" (2010), and the 10th International Conference on Intersubband Transitions in Quantum Wells (2009).

I am currently serving as the chair of the IEEE Photonics Society Central Texas Chapter, and I also make regular contributions to the Optical Society of America research highlights journal "The OSA Spotlight on Optics."

I regularly provide peer reviews for the most important journals in my area as well as for research proposals for National Science Foundation, Swiss National Science Foundation, French National Research Agency, and Qatar National Research Fund. While in rank, I have provided approximately 50 peer-reviews for various journals including Nature Photonics, Nature Communications, Physical Review Letters, Applied Physics Letters, Optics Letters, Optics Express, IEEE Journal of Quantum Electronics, IEEE Journal of Selected Topics in Quantum Electronics, IEEE Photonics Technology Letters, Laser & Photonics Reviews, Optics Communications, Microelectronic Engineering, and the Journal of Physical Chemistry.

Identifying fraud and technical flaws in publications, especially in high-impact ones, is an important part of the service to the scientific community. I was part of the team that identified significant technical flaws in one of the reports published in the Nature Photonics journal (the most selective journal in optics and photonics), which led to the paper retraction in March 2013.

I also participate in a number of NSF-sponsored programs to promote and improve Science, Technology, Engineering and Mathematics education. Since 2011, I have served as a summer research supervisor to undergraduate students from all over the nation taking part in the NSF National Nanotechnology Infrastructure Network Research Experience for Undergraduates Program. This summer I am participating in the UTeachEngineering Master of Arts in Science, Technology, Engineering, and Mathematics Education as a master's thesis summer research supervisor for a high school teacher.

Budget Council Assessment of Honors and Other Evidence of Merit or Recognition, Including Contracts and Grants for Promotion Candidate Mikhail Belkin

Prepared by Ananth Dodabalapur, Budget Council Member

This assessment is based on Dr. Belkin's statements and resume. It represents my interpretation/evaluation of the various honors, and honorific grants that he has received. This is followed by a summary statement placing these details in perspective. Some information (in italics) about these awards has been obtained from websites of several agencies.

Part I: Young Investigator Awards

Dr. Belkin has received several important awards. Significantly, these awards were received for different aspects of his research work. All these awards are very competitive.

NSF Faculty Early Career Development Program (CAREER, 2012)

The Faculty Early Career Development (CAREER) Program is a Foundation-wide activity that offers the National Science Foundation's most prestigious awards in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations. Such activities should build a firm foundation for a lifetime of leadership in integrating education and research (NSF Website).
Dr. Belkin received this award for his work on room temperature terahertz quantum cascade lasers. This is a distinction that serves to identify and reward future leaders. It is very competitive, and having served on a panel recently that helped decide such awards, I can attest that the proposals are highly competitive. Receiving such an award requires the writing of an outstanding proposal.

DARPA Young Faculty Award 2012

The objective of the DARPA Young Faculty Award (YFA) program is to identify and engage rising research stars in junior faculty positions at U.S. academic institutions and expose them to Department of Defense needs as well as DARPA's program development process.
Typical YFA efforts are 2-year projects in 12 topic areas spanning the physical, biological, social, and engineering and computer sciences. In recognition of the diverse backgrounds of research faculty at US institutions, YFA eligibility is not limited to US citizens.
About 15-20 scientists/engineers receive such an award at any one time, according to the DARPA website. Dr. Belkin received this award for his work on room temperature terahertz-quantum cascade lasers.

AFOSR Young Faculty Award (2009)

This award was for plasmonic metamaterials in the mid-infrared spectral range. Significantly, he received this award within two years of joining UT Austin. The AFOSR award is for *candidates who show exceptional ability and promise for conducting basic research. The objective of this*

program is to foster creative basic research in science and engineering; enhance early career development of outstanding young investigators; and increase opportunities for the young investigator to recognize the Air Force mission and related challenges in science and engineering.

Norman Hackerman Advanced Research Program Award (2012)

This award was for research to develop nonlinear metamaterials for mid-infrared second harmonic generation. He was one of 12 awardees for the year from among non-tenured faculty across the state of Texas.

Other Awards: Dr. Belkin is an IEEE Senior Member. He has also received a fellowship during his graduate career at UC Berkeley.

II. External Research Funding

He has received competitive funding from various agencies, including several single PI grants: National Science Foundation, AFOSR, DARPA, Welch, and the Texas Higher Education Coordinating Board. He has also received two awards from NSF and one from the THECB with a co-investigator. Additional details regarding his awards can be found in his CV. The large number of awards from NSF, which are highly competitive, is especially noteworthy.

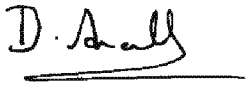
III. Speaking Invitations

While at UT Austin, Dr. Belkin has presented 20 invited talks at research conferences including major conferences such as CLEO, CLEO-Europe, Photonics West, and the Materials Research Society meetings. This is a clear indicator of the high degree of recognition that his work has achieved.

IV. Summary Statement

Dr. Mikhail Belkin has received numerous young investigator awards, and is very well paced in this regard among his peer group. He has also received highly competitive grants from various funding agencies, especially from NSF. His share of funding is ~ $ 2.5M, a very healthy figure, and exceeds the average for our department.

Statement prepared by Ananth Dodabalapur, Budget Council Member



Honors and other Evidence of Merit or Recognition, Including Contracts & Grants

Mikhail A. Belkin
Department of Electrical and Computer Engineering, The University of Texas at Austin
mbelkin@ece.utexas.edu

1. Young Faculty Awards

I was fortunate to receive a number of young faculty awards to support my research, including the AFOSR Young Investigator Program award (2009), the NSF CAREER award (2012), the DARPA Young Faculty Award (2012), and the Norman Hackerman Early Career Investigator Award from the state of Texas (2012).

It is worth mentioning that these awards were given for different aspects of my research program. In particular, the AFOSR Young Investigator Program award was given for research on plasmonic metamaterials in mid-infrared spectral range, the NSF CAREER award and the DARPA Young Faculty Award were given for research on room temperature terahertz quantum cascade laser sources, and the Norman Hackerman Early Career Investigator Award from the state of Texas was given for research to develop nonlinear metamaterials for mid-infrared second harmonic generation.

2. Research funding

My funding comes from a large variety of federal, state, and private sources, including NSF, DARPA, DOE, AFOSR, ARO, the Welch Foundation, and the state of Texas grants. None of the sources listed above represent a majority of my cumulative funding total, which is best to ensure the continuity of research. My CV provides further details on funding.

3. Invited Conference Talks

Since the start of my career at the University of Texas at Austin, I have presented 20 invited talks at major research conferences, including CLEO, CLEO-Europe, Photonics West, and the Materials Research Society Meeting. The number of invitations to present my research at the leading conferences has increased significantly in recent years thanks to the high-impact research results produced at the University of Texas. In particular, I have presented seven invited talks in 2013 with several more planned–including two invited talks at Photonics West Conference and one invited talk at CLEO conference. These two conferences are considered to be the two most important professional meetings on lasers and photonics. My CV provides further details on conference talks, including invited talks and forthcoming talks.

Chart of External Reviewers
Mikhail Belkin
Electrical and Computer Engineering Department

Name	Title	Institution	Chosen By Candidate/BC	Date Received	Reason for Declination
RECEIVED					
Daniel Botez	Philip Dunham Reed Professor of Electrical Engineering, Director, Reed Center for Photonics	University of Wisconsin-Madison	Candidate	7/22/2013	
	Fellow of IEEE, OSA, TRW Technical Fellow, OSA Nick Holonyak Jr. Award -- Dr. Botez was chosen for his research interests in the areas of semiconductor-laser physics; high-power coherent edge-emitting lasers; and quantum cascade lasers.				
James J. Coleman	Intel Alumni Endowed Chair in Electrical and Computer Engineering	University of Illinois at Urbana-Champaign	BC	6/24/2013	
	Fellow of OSA, IEEE, SPIE , IEEE William Streifer Scientific Achievement Award, IEEE Lasers and Electro-Optics Society (LEOS) Award, IEEE LEOS Distinguished Lecturer, Member National Academy of Engineering -- Dr. Coleman was chosen for his research interests in the development of III-V semiconductor lasers and photonic devices grown by metalorganic chemical vapor deposition (MOCVD).				
Yeshaiahu Fainman	Cymer and Distinguished Professor of ECE and Chair of Electrical and Computer Engineering Department	University of California, San Diego	BC	8/10/2013	
	Fellow of OSA, SPIE, IEEE -- Dr. Fainman was chosen for his research interests in applied optics and photonics; optical communications and interconnections; nanophotonics; ultrafast optics; optical information processing systems; nonlinear and diffractive optics, coherence properties of optical field scattered from a moving phase screen; photonic networks.				
Jerome Faist	Professor	ETH Zurich	Candidate	7/5/2013	
	Co-inventor of QCLs (with Federico Capasso), Co-founded Alpes Lasers, IEEE/LEOS William Streifer Award (1998), International Symposium for Compound Semiconductors Award (1999), the National Swiss Latsis Prize (2002). (h-index-60) -- Dr. Faist was chosen for his research interests in the development of mid-infrared and terahertz quantum cascade lasers and frequency combs, the physics of strong light-matter coupling in metallic resonators and quantum dots intraband devices.				
Qing Hu	Professor	Massachusetts Institute of Technology	Candidate	7/9/2013	
	Fellow of AAAS, APS, IEEE, OSA, 2012 IEEE Photonics Society William Streifer Scientific Achievement Award -- Dr. Hu was chosen for his research interests focusing on the development of high-temperature, high-power, high beam-quality, and broadly tunable THz QCLs; THz amplifiers; ultrafast time- and phase-resolved study of dynamics in quantum structures; sensing and real-time imaging THz systems for a variety of applications including remote sensing, biomedical imaging, and security.				
Jerry R. Meyer	Navy Senior Scientist and Acting Head of the Quantum Optoelectronics Section of the Optical Sciences Division	Naval Research Laboratory	BC	7/20/2013	
	Fellow of APS, OSA, IEEE, Institute of Physics, SPIE -- Dr. Meyer was chosen as a research physicist conducting investigations of optical and transport properties of narrow-gap IR detector materials.				

Chart of External Reviewers
Mikhail Belkin
Electrical and Computer Engineering Department

Marlan O. Scully	Director, Institute for Quantum Studies, Burgess Distinguished Professor, TEES Distinguished Research Professor	Texas A & M University	Candidate	7/21/2013	
	Member National Academy of Science, American Academy of Arts & Sciences, Fellow of OSA, APS, AAAS, APS Arthur L. Schawlow Prize, IEEE Quantum Electronics Award, OSA Charles H. Townes Award, The Franklin Institute Elliott Cresson Medal -- Dr. Scully was chosen for work in theoretical quantum optics.				
Carlo Sirtori	Professor	University Paris-Diderot	Candidate	7/19/2013	
	European Physical Society Fresnel Prize (2002), International Symposium for Compound Semiconductors Award (2006), Member of the Institut Universitaire de France, EPS Fresnel Prize, APS Quantum Devices Award (h-index=49) -- Dr. Sirtori was chosen for his research focused on the demonstration of innovating devices such as the first quantum cascade laser in the GaAs/AlGaAs material system, the first Sb-based QCLs and the development of plasmonic waveguides for GaAs.				
Frank K. Tittel	J. S. Abercrombie Professor	Rice University	BC	8/8/2013	
	Fellow of IEEE, OSA, APS, Associate Editor of *Applied Physics B* -- Dr. Tittel was chosen for his involvement in many innovative developments in quantum electronics and laser technology since the discovery of the laser in 1960, with applications ranging from laser spectroscopy to environmental monitoring. His current research activities have led to the development of several advanced, state of the art, computerized laser spectrometers.				
Konstantin Vodopyanov	21st Century Scholar Chair & Professor of Optics	University of Central Florida	BC	8/6/2013	
	Fellow of APS, SPIE, OSA, Institute of Physics, Senior member of IEEE --Dr. Vodopyanov was chosen for his research interests in nonlinear optics, laser spectroscopy, biomedical applications of lasers, mid-IR and terahertz-wave generation, broadband IR frequency combs and their spectroscopic applications, and nano-IR microscopy.				
Decline	none				
No response	none				

COCKRELL SCHOOL OF ENGINEERING
THE UNIVERSITY OF TEXAS AT AUSTIN

Department of Electrical and Computer Engineering • Engineering Science Building
1 University Station C0803 • Austin, Texas 78712-0240 • (512) 471-6179 • Fax (512) 471-3652

June 18, 2013

Dear Dr. Botez:

The Department of Electrical and Computer Engineering is considering Dr. Mikhail Belkin for tenure and advancement in rank to the position of Associate Professor at The University of Texas at Austin. The two main criteria for promotion are demonstrated scholarship and excellent teaching. We would particularly appreciate your candid assessment of his scholarly contributions. Although we recognize that it is unlikely that you have firsthand knowledge of his teaching, any information you do have with this respect to this would also be welcome. A copy of the candidate's curriculum vitae is enclosed. To provide context, I should note that The University of Texas at Austin normally considers a faculty member for promotion to Associate Professor upon completion of five years in probationary status. Professor Belkin has accumulated five years of service in probationary status, so this review is taking place at the normal time for tenure evaluation.

Your assessment of Professor Belkin would be most helpful if you could address the following questions:

1. Do you know Professor Belkin, and if so, for how long and under what circumstances?
2. How would you assess the contributions to your discipline made by Professor Belkin's publications? Which publications would you judge to be the most significant, and why?
3. How would you assess Professor Belkin's development as a scholar/researcher compared with others in his cohort at research-intensive universities?
4. What is your perspective on Professor Belkin's promise for further growth and significant contributions to his field?

The following link provides you access to Professor Belkin's CV, recent publications and research and teaching statements to assist you in this task:

To access the site please use the following login and password:

Website: https://fuze1.ece.utexas.edu/eceapps/promotion
Login: cand0601
Password: 6NNEgf

Please let us know if you prefer to receive this material via email or regular mail.

We would be grateful for any additional comments you might have.

Under the laws of the State of Texas, Professor Belkin has the right to request to see any materials in his personnel file, including your letter. Although Professor Belkin has waived that right, it is not clear whether he can reinstate that right at some future time. It is also the case that the members of our internal review committees will see your letter as part of the promotion process. They will hold the comments you make in confidence. Please know that we will make every attempt to hold the contents of your letter confidential within all limits of the law.

We would appreciate receiving your letter no later than July 25, 2013. Please enclose a copy of a short version of your curriculum vitae or résumé (preferably no longer than one page) or the URL for your Website where we may obtain this information. While electronic letters or PDF are fine, our guidelines require that you either sign your letter or include an electronic signature. If you have any questions about this, please do not hesitate to contact me at your convenience at 512-471-6971.

I want to personally thank you for your time and assistance with this important matter. I recognize that the amount of time required to do a thoughtful review is considerable.

Sincerely,

Dr. Ahmed Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Department of Electrical and Computer Engineering
The University of Texas at Austin
Austin, Texas 78712-0240

M.A. Belkin – Five Most Significant Publications While in Rank

This document identifies the five most significant peer-reviewed publications produced while in rank at UT Austin.

1. K. Vijayraghavan, Y. Jiang, M. Jang, A. Jiang, K. Choutagunta, A. Vizbaras, F. Demmerle, G. Boehm, M. C. Amann, and M. A. Belkin "Broadly-tunable terahertz generation in mid-infrared quantum cascade lasers," *Nature Comm.* **4,** 2021 (2013). http://dx.doi.org/10.1038/ncomms3021
2. K. Vijayraghavan, R.W. Adams, A. Vizbaras, M. Jang, C. Grasse, G. Boehm, M. C. Amann, and M.A. Belkin "Terahertz Sources Based on Čerenkov Difference-Frequency Generation in Quantum Cascade Lasers," *Appl. Phys. Lett.* **100,** 251104 (2012). http://dx.doi.org/10.1063/1.4729042
3. Y. Zhao, M.A. Belkin, and A. Alu, "Twisted optical metamaterials for planarized, ultrathin, broadband circular polarizers," *Nature Comm.* **3,** 870 (2012). http://dx.doi.org/10.1038/ncomms1877
4. F. Lu and M.A. Belkin, "Infrared absorption nano-spectroscopy using sample photoexpansion induced by tunable quantum cascade lasers," *Optics Express* **19,** 19942-19947 (2011). http://dx.doi.org/10.1364/OE.19.019942
5. J. Lee, F. Lu, and M.A. Belkin, "Broadly wavelength tunable bandpass filters based on long-range surface plasmon polaritons," *Opt. Lett.* **36,** 3744-3746 (2011). http://dx.doi.org/10.1364/OL.36.003744

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botez@engr.wisc.edu

July 22, 2013

Dr. Ahmed Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Department of Electrical and Computer Engineering
The University of Texas at Austin
Austin, Texas 78712-0240

Re: Letter of recommendation regarding the consideration for promotion of Dr. Misha Belkin to the rank of Associate Professor with tenure at UT-Austin

Dear Professor Tewfik,

I have known Misha Belkin since 2006 when he was a PhD candidate in Federico Capasso's group at Harvard. Ever since then I have been aware of his work and interacted with him at professional conferences as well as workshops on Quantum Cascade Lasers (QCLs). He has always impressed me as a highly intelligent scientist possessed of a no-nonsense attitude of implementing new device concepts not only for achieving scientific breakthroughs but also for realizing novel devices of practical use.

As for his scientific contributions, first and foremost is his remarkable work on THz QCLs. When tackling the problem of how to increase the operating temperature of THz QCLs, he produced several high-quality papers, of which the one in the IEEE Trans. THz Sci. Technology can be considered a "classic", clarifying what fundamentally limits the performance of THz QCLs. Then, he pursued THz generation via intracavity nonlinear processes in mid-IR QCLs and, while he obtained THz emission at room temperature the output powers were negligible. His breakthrough, which may well turn out to be revolutionary for the THz-QCL field, was the conception and realization of the Cherenkov DFG scheme, that allowed record-high room-temperature powers as well as tunability over a wide frequency range [just published in high-impact factor (i.e., 10) multidisciplinary-sciences journal Nature Communications].

The significance of Misha Belkin's recent achievements in the THz QCL field is attested by the numerous invited talks at high profile, international conferences such as the IEEE/OSA Conference on Lasers and Electro-Optics (CLEO). I believe that his approach has the potential to generate tens of mWs of THz radiation at room temperature; thus, resulting in the practical THz devices that many researchers have worked on and dreamed of for over 12 years by now.

The other major scientific contribution has been in subwavelength-resolution microscopy by using mid-IR QCLs to match the resonance frequency of AFM cantilevers. Quite ingenious AFM

tip enhancement of light intensity has resulted in record-low (30 nm) spatial resolution for use in molecular spectroscopy. The exciting potential that Prof. Belkin's microscopy technique holds is the ability to do spectroscopy of single molecules, which, in turn, would open a whole new area of research in molecular physics as well as a multitude of practical applications.

In view of the above comments, I consider his most significant publications to be:

- K. Vijayraghavan, Y. Jiang, M. Jang, A. Jiang, K. Choutagunta, A. Vizbaras, F. Demmerle, G. Boehm, M. C. Amann, and M. A. Belkin, "Broadly tunable terahertz generation in mid-infrared quantum cascade lasers," *Nature Comm.* 4, 2021-1 – 2021-7 (June 2013).
- K. Vijayraghavan, R.W. Adams, A. Vizbaras, M. Jang, C. Grasse, G. Boehm, M.C. Amann, and M.A. Belkin, "Terahertz sources based on Čerenkov difference-frequency generation in quantum cascade lasers," *Appl. Phys. Lett.* 100(25), 251104-1 – 251104-4 (June 2012).
- F. Lu and M.A. Belkin, "Infrared absorption nano-spectroscopy using sample photoexpansion induced by tunable quantum cascade lasers," *Optics Express* 19(21), 19942-19947 (Sept. 2011).

Misha Belkin's publication record is quite impressive in that it includes numerous papers in high-impact journals: 12 in Appl. Phys. Lett., 10 in Opt. Express, 3 in Phys. Rev. Lett., and 2 in Nature Comm. He has also published extensively in high-impact archival journals, most notable being the Invited Paper in the IEEE/OSA Journal of Selected Topics in Quantum Electronics (Impact Factor: ~ 4). The impact as well as the quality of his scientific endeavors is clear from his Google Citations profile; in that, an h-index of 25 is quite remarkable for a young scientist.

Comparing Misha Belkin with other scientists of his generation at research universities, I have to say the following. I consider his scientific contributions to be superior to those by Prof. Ben Williams (UCLA) and about the same as those of Prof. Sushil Kumar (Lehigh Univ.). I also consider him to be the most accomplished scientist to have come out, to date, from Federico Capasso's group at Harvard University.

As for his ability for teaching I can assess it only from the various presentations I heard Misha Belkin give. He presents complex concepts in a clear, intuitive manner; thus, I surmise he is an excellent teacher.

The future looks bright for Misha Belkin. Not only is he making breakthroughs in two fields (i.e., THz QCLs and molecular spectroscopy), but he has already positioned himself well for making significant contributions in the hot new applied-physics fields of plasmonics and metamaterials.

Therefore, I strongly recommend, with absolutely no reservations, Misha Belkin's promotion to Associate Professor with tenure at University of Texas at Austin. I am confident he'll continue to be a highly valuable asset to your department and university.

Sincerely yours,

Dan Botez
Philip Dunham Reed Professor of Electrical Engineering
Director, Reed Center for Photonics

Jilda Gayle

From: Dan Botez <botez@engr.wisc.edu>
Sent: Monday, July 22, 2013 9:40 PM
To: Bearden, Carole A
Cc: Tewfik, Ahmed H; Jilda Bolton (jildagayle@gmail.com)
Subject: Re: Letter of reference for Dr. Mikhail Belkin
Attachments: Dr. Misha Belkin-Letter of Recommendation.pdf; Untitled attachment 00003.htm; D. Botez- Brief CV and relevant links.pdf; Untitled attachment 00006.htm

Dear Dr. Tewfik,

Attached please find my letter of reference for Misha Belkin as well as a brief CV with relevant links.

With best regards,

Dan Botez

Dan Botez,
Philip Dunham Reed Professor of Electrical Engineering (EE) at University of Wisconsin (UW)-Madison and Director of the Reed Center for Photonics.

He obtained his Ph.D. degree in EE from Univ. of California, Berkeley in 1976. After joining RCA Labs, Princeton, NJ (1977) he created novel types of high-power single-mode diode lasers, one of which became the highest-power commercially available single-mode diode laser during 1981-1986. In 1986 he joined, as Senior Staff Scientist, TRW Res. Ctr., Redondo Beach, CA, where he continued his work on high-power coherent diode lasers. He is co-inventor of the concept of resonant leaky-wave coupling in phase-locked arrays of antiguides (1988) which led to *the first* Photonic-Crystal (PhC) laser structure for high-coherent-power generation. As a result, in 1990 he led the team that "broke" the 1-Watt coherent-power barrier for diode lasers, and later achieved 1.6 W CW near-diffraction-limited beam operation. At UW-Madison he focused on high-power, Al-free lasers and achieved record-high CW power (11W) and CW wallplug efficiency (66%). In 2001 he solved the long-standing problem of obtaining single-lobe beam operation from 2nd-order distributed-feedback (DFB) lasers at *no penalty* in efficiency. The novel concept: surface-emitting DFB lasers with grating π phase shift, was experimentally confirmed by his group in 2003. Ever since many other groups have used the π-phase-shift concept to obtain single-lobe surface emission either from 1-D or 2-D PhC lasers, spanning the spectrum from the near-IR to the THz range. He has also focused on quantum cascade lasers (QCLs) which led to the invention of the deep-well (DW) and Tapered Active-Region (TA) QCLs (2004 and 2010). With DW and TA QCLs his team suppressed carrier leakage from the QCL active regions, as manifested by threshold currents which vary *half as fast* as those for conventional 4.6-4.8 μm QCLs and slope efficiencies which vary only *one fifth as fast* as those for conventional 4.6-4.8 μm QCLs; thus holding the potential to significantly improve the CW performance *and* reliability of QCLs.

Dr. Botez is the recipient of the OSA 2010 Nick Holonyak Jr. Award for fundamental contributions to the development of high-power semiconductor lasers, including photonic-crystal laser structures for high coherent power generation. He has authored or coauthored more than 400 publications (h-index = 37) of which over 300 were refereed, and holds 51 patents.

Awards and Honors:
- Nick Holonyak Jr. Award, Optical Society of America, 2010
- Fellow of the Optical Society of America, 1995
- Fellow of the Institute of Electrical and Electronic Engineers (IEEE), 1986
- Outstanding Young Engineer of the Photonics Society, and Key to the Future Award (IEEE Centennial), 1984
- RCA Outstanding Achievement Award, 1979
- B.S. (High. Hons.) *Summa Cum Laude*, University of California, Berkeley
- Phi Beta Kappa, 1971.

PROFESSIONAL SOCIETY ACTIVITIES
- Editorial Board of the Journal of Physics D: Applied Physics (2013-on)
- Aron Kressel IEEE Photonics Society Award Committee: Chairman (2011)
- Nick Holonyak Jr. OSA Award Committee: Member (2006-2007), Chairman (2007-2008)
- Associate Editor: IEEE Photonics Technology Letters (2003-2011)
- Associate Editor: IEEE Journal of Quantum Electronics (1996-2002)
- Guest Co-Editor: Special Issue on Semiconductor Lasers, IEEE Journal of Selected Topics in Quantum Electronics, June 1995.
- IEEE Lasers and Electro-Optics Society (LEOS): Board of Governors Member (1993-1995)
  - Technical Committee on Semiconductor Lasers (1982-1992) (Chairman: 1989-1990)
- IEEE/LEOS Engineering Achievement Award Committee, Member, 1991, 1992.
- Editorial Board of the IEEE Spectrum Magazine (1989-1991)
- IEEE/LEOS Fellows Selection Committee, Member, 1989.
- Co-Founder of the IEEE International Workshop on Semiconductor Laser Device Physics (1984) and Chairman of the 1984 and 1985 workshops. The workshop is now held annually.

PROFESSIONAL CONFERENCE ACTIVITIES
- The European Conference on Lasers and Electro-Optics and the XIIth European Quantum Electronics Conference (CLEO/Europe-EQEC) - Semiconductor Lasers Subcommittee Member: 2011, 2013.
- IEEE/OSA Conference on Lasers and Electro-Optics (CLEO)
  - General Co-Chair: 2006-2007

- Program Co-Chair: 2004-2005
- Semiconductor Lasers Subcommittee Chair: 1997-1998; 1998-1999.
- Semiconductor Lasers Subcommittee Member: 1993, 1994, 1995, 1996, 2000

• IEEE International Semiconductor Laser Conference
- Americas' Committee Chair: 2000
- Program Committee Member: 1982, 1984, 1988, 1990, 1996, 1998.

Selected Publications

1) "Multidimensional Conduction-Band Engineering for Maximizing the Continuous-Wave Wallplug Efficiencies of Mid-Infrared Quantum Cascade Lasers", D. Botez et al.,(Invited Paper), *IEEE J. Selected Topics Quantum Electron.*,Vol. 19, article no. 1200312, Jul./Aug. 2013, pp. 1–12.
2) "Temperature Dependence of the Key Electro-Optical Characteristics for Midinfrared Emitting Quantum Cascade Lasers", D, Botez et al., *Appl. Phys. Lett.*, Vol. 97, p. 071101, Aug. 2010.
3) "Analysis of Surface-Emitting 2nd-order Distributed Feedback Lasers with Central Grating Phaseshift", S. Li, G. Witjaksono, S. Macomber and D, Botez, *IEEE J. Sel. Top. Quantum Electron.*, Vol. 9, pp.1153-1165, Sept. 2003.
4) "Design Considerations and Analytical Approximations for High Continuous-Wave Power, Broad-Waveguide Diode Lasers", D. Botez, *Appl. Phys. Lett.*, Vol. 74, pp. 3102-3104, May 1999.
5) "Phase-Locked Arrays of Antiguides: Modal Content And Discrimination," D. Botez, L.J. Mawst, G. Peterson and T. Roth, *IEEE J. Quantum Electron.*, Vol. 26, pp. 482-495, March 1990.

Relevant Links

Google Citations Profile: http://scholar.google.com/citations?user=jPY8wHQAAAAJ&hl=en

List of Publications, Patents and Invited Presentations:
http://webpages.charter.net/botez/PDF_files/List_of_Publications_Patents_and_Invited_Presentations.pdf

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

James J. Coleman
Intel Alumni Endowed Chair in Electrical and Computer Engineering

June 24, 2013

Ahmed Tewfik, Professor and Chair
Cockrell Family Regents Chair in Engineering
Department of Electrical and Computer Engineering
University of Texas,
Austin, TX 78712-0240

Dear Professor Tewfik,

I am writing this letter of reference for **Mikhail A. Belkin** who is, I understand, a candidate for tenure and advancement in rank to the position of Associate Professor at The University of Texas at Austin. I do not know Prof. Belkin well personally, although we have met on more than one occasion. I am certainly aware of his career and am familiar with his research. I am also keenly aware of the importance of hiring and retaining the highest quality young people for junior-level faculty positions. I have been a member of my department's faculty search committee for some years and consider this job to be the most important committee assignment I have held.

Promotion at Illinois is based roughly on 40% teaching, 40% research, and 20% service to the campus and professional community. Apart from his interesting presentations at conferences, I am unable to assess his teaching. I can, I think, speak credibly to the other categories. For promotion to Associate Professor with tenure, we expect a candidate to have firmly established his or her research career and demonstrated potential for a significant international reputation. I think on balance that Prof. Belkin has significantly exceeded those expectations.

For his research, Prof. Belkin has become a well-known and prolific contributor to the area of quantum cascade lasers. It is an interesting and exciting area of great current research, one that has enormous potential impact, and one in which there are a remarkable number of very fine scientists. For example, there are incredible senior scientists such as Capasso and Gmachl (who are among Prof. Belkin's collaborators and mentors) and a host of truly exceptional junior scientists in academia such as Ben Williams at UCLA, Alexandra Boltesseva at Purdue, and Dan Wasserman at Illinois. Prof. Belkin is as strong as all of the young people I have mentioned here and on a clear vector to equaling the career of Gmachl and potentially approaching that of Capasso. To be very clear, I am intending to send the message that the bar is set very high and Prof. Belkin is answering the challenge very well.

Department of Electrical and Computer Engineering *Micro and Nanotechnology Laboratory*
208 North Wright Street Urbana, Illinois 61801 jcoleman@illinois.edu telephone 217-333-2555

Specifically, Prof. Belkin has been developing novel approaches to some critical issues associated with quantum cascade lasers – specifically higher temperature operation and broad band tunability. He has been a co-author on two highly cited contributions to these sticky problems (Lee, Belkin, et al. *Applied Physics Letters*, v 91, p 231101-1-3, 2007 and Belkin, et al. *IEEE Journal on Selected Topics in Quantum Electronics*, v 15, p 952-967, 2009). This work has also been the subject of a number of invited papers for Prof. Belkin and has resulted in recognition for him in the form of several Career and Young Faculty awards. Most young faculty would be delighted to receive one of these awards and Prof. Belkin has won four!

So, in summary, I am delighted to give Prof. Belkin the strongest possible recommendation. He is bright, creative, and prolific. He has a strong record in publications and presentations and even patents. He is clearly a credit to Texas and anything you can do to keep him happy there is a wise investment.

Sincerely,

James J. Coleman

Jilda Gayle

From: Bearden, Carole A <cjjp@mail.utexas.edu>
Sent: Monday, June 24, 2013 3:31 PM
To: Tewfik, Ahmed H; Jilda Bolton (jildagayle@gmail.com)
Subject: FW: Letter of Reference for Dr. Mikhail Belkin
Attachments: BelkinTexas2013.pdf

Importance: High

FYI

From: Coleman, James J [mailto:jcoleman@illinois.edu]
Sent: Monday, June 24, 2013 2:56 PM
To: Bearden, Carole A
Subject: RE: Letter of Reference for Dr. Mikhail Belkin

Carole,

Please find my letter attached.

Best wishes,
Jim

James J. Coleman Intel Alumni Endowed Chair in Electrical and Computer Engineering | Department of Electrical and Computer Engineering | University of Illinois | Micro and Nanotechnology Laboratory | 208 North Wright Street | Urbana, Illinois 61801 | ☎: (217) 333-2555 | ✉: jcoleman@illinois.edu

IEEE Photonics Society Past-President 2012-2013 | ✉: j.coleman@ieee.org | http://www.PhotonicsSociety.org

From: Bearden, Carole A [mailto:cjjp@mail.utexas.edu]
Sent: Tuesday, June 18, 2013 4:03 PM
To: Coleman, James J
Cc: Tewfik, Ahmed H; Jilda Bolton (jildagayle@gmail.com)
Subject: Letter of Reference for Dr. Mikhail Belkin
Importance: High

Dr. Coleman,

Thank you for your support of Dr. Mikhail Belkin's promotion and agreeing to write a recommendation letter. Attached is a formal request for the letter with a website, logon and password to access his information as well as his CV.

Best regards,

Carole Bearden
Executive Assistant
The University of Texas at Austin
Electrical and Computer Engineering
ENS Room 236
2501 Speedway, C0803

CHAIRS, PROFESSORSHIPS, AND FACULTY SCHOLARS

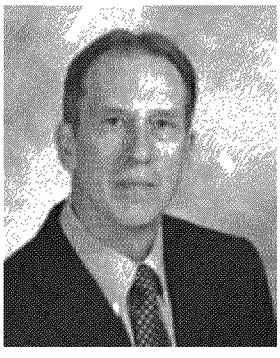
Chair: Intel Alumni Endowed Chair in Electrical and Computer Engineering

[This] chair signals a growing partnership between ECE and Intel—already, a number of ECE alumni have established successful careers at Intel, and Intel has donated equipment to ECE's Integrated Circuit Fabrication Laboratory.

As Intel's senior sponsor for the University of Illinois, ECE alumnus Mark Bohr (MSEE '78) approached the College of Engineering's development office a few years ago with the idea for the endowed chair. Bohr, Intel's director of Process Architecture and Integration, then gathered support from other ECE alumni working at Intel.

In addition to Mark and Jean Bohr, other major contributors included Jerry (BSEE '73, MSEE '76, PhD '78) and Michelle Marcyk, Carl (BSEE '74) and Patricia Simonsen, Alan (MS-physics '75, PhD '79) and Carole Stivers, Leo (PhD '69) and Bella Yau, and Intel cofounder Gordon Moore and his wife Betty. The chair was created to recruit or retain a top researcher in integrated circuit technology within the department.

Faculty: James J. Coleman



James J. Coleman

Professor James J. Coleman is a faculty member in the Department of Electrical and Computer Engineering and the Materials Science and Engineering Department. He joined the Illinois faculty in 1982, after a six-year career in industry. As a member of the technical staff at Bell Laboratories (1976-78), he studied the growth and processing of long-wavelength lasers, and he developed high-performance lasers for early fiber-optic telecommunications systems. At Rockwell International (1978-82), he demonstrated the first AlxGa1-xAs-GaAs self-aligned laser structure, which is presently used in commercial compact disc lasers and high-power lasers for optical storage and medical applications.

Coleman's current research interests focus on the development of III-V semiconductor lasers and photonic devices grown by metalorganic chemical vapor deposition (MOCVD). He and his students are studying quantum well heterostructures, superlattices, and low threshold single mode lasers and high power index guided laser arrays. They have demonstrated reliable low threshold index guided lasers, integrable distributed feedback lasers, and high power laser arrays (?>1μm) from lattice-mismatched strain-accommodated InGaAs-GaAs heterostructures.

Among his many awards and honors are the William Streifer Scientific Achievement Award, the IEEE Lasers and Electro-Optics Society (LEOS) Award for pioneering research in high reliability strained layer semiconductor lasers, and the IEEE LEOS Distinguished Lecturer distinction. He is a Fellow of the American Physical Society, American Association for the Advancement of Science, Optical Society of America, and IEEE.

An Illinois electrical engineering alumnus, Coleman earned his bachelor's degree (high honors) in 1972; he earned his master's and doctoral degrees in 1973 and 1975, respectively.

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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
9500 GILMAN DRIVE LA JOLLA, CALIFORNIA 92093-0407
Y. Fainman
858-534-8909
fainman@ece.ucsd.edu

August 10, 2013

Prof. Ahmed Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Department of Electrical and Computer Engineering
The University of Texas at Austin
Austin, Texas 78712-0240

Dear Professor Tewfik:

This letter is in response to your correspondence dated June 18, 2013 requesting assistance in evaluation of Dr. Mikhail Belkin's scholarship and outstanding contributions in the field of his research on novel optoelectronic and optomechanical devices, metamaterials, and photonic systems operating in mid-IR and THz frequency range in support of his promotion to rank of Associate Professor with tenure in the Department of Electrical and Computer Engineering at The University of Texas at Austin. The assessment is based on his resume, a few representative journal publications of Dr. Belkin as well as personal interactions.

I have known Dr. Belkin by reputation since 2003 and personally since 2007 when he was a postdoc in Capasso's group, and I have had a number of interactions with him at professional conferences and workshops. Dr. Belkin stands out in comparison with his peers in terms of originality and ability to analyze complex physical concepts on better understanding fundamental phenomena and utilizing it for applications to design photonic components and devices utilizing photonic properties of composite semiconductors. For example, his group at UT Austin realized that InGaAs/AlInAs/InP materials system used for mid-IR quantum cascade lasers (QCL) is ideal for implementing QCL sources based on Cherenkov difference-frequency generation (DFG) in which optical nonlinearity with population inversion may be integrated into the active region of the device and THz radiation can be derived into an undoped InP substrate across the footprint of the laser waveguide (Appl. Phys. Lett.100, 251104, 2012). More recently, this work was extended further via optimization of the active region and waveguide design for operation at room temperature providing record performances: 120 μW of peak power output at 4 THz and tunability in 1.7- 5.3 THz range (Nature Comm.-2013).

Another example is work of Dr. Belkin on subwavelength resolution microscopy, where he and his students initiated work on using QCL for spectroscopic measurements since their power densities are smaller than these used for such measurements. Their approach was quite clever: they set the repetition frequency of light pulses from QCLs driven by a current source to match the mechanical resonance frequency of the AFM cantilever. In this case the cantilever deflection amplitude is enhanced by the quality factor (Q-factor) which can be as high as 5000 in air. Using this approach, QCL-based mid-IR spectroscopy was demonstrated fo 50 nm thin samples with spatial resolution of 50 nm (Optics Express 19,19942, 2011). Most recently, this work was extended to use nano-

antennas and metalized AFM tips to further enhance the sensitivity and spatial resolution of the technique for photoexpansion microscopy, where the spatial resolution is determined by the dimension of the hot spot (similar to HAMR) as opposed to thermal diffusion. This method allowed achieving mid-IR spectroscopy of molecular monolayer islands with better than 30 nm spatial resolution. The estimated sensitivity is about 100 molecules, makes it one of the most sensitive in-situe mid-IR spectroscopic techniques (http://users.ece.utexas.edu/~mbelkin/microscopy_preprint.pdf). In short, Dr. Belkin has clearly demonstrated that he has what it takes to come up with an original, meaningful idea and develop the underlying analysis method for quantitative design of the components and devices, and exploring their practical applications collaborating with his students and collegaues. His research work is clearly high class.

Dr. Belkin has been applying his basic knowledge to carry out exciting research projects and authored and co-authored over fifty manuscripts in top quality peer review journals in the field. It is evident that he has done a number of original and significant contributions while being a student at UC Berkeley and a postdoc back at Harvard as he has been a first author on 13 manuscripts. His h-index of 22 is a significant accomplishment at his stage in career. Since joining UT Austin in 2008, he established his own research group and clearly demonstrated independence of his research program as his publications are primarily with his students and with some of his colleagues. He also is very active at high quality technical conferences, symposia, and workshops. He has presented an appreciable number of invited papers, which is a clear indication to his standing in the field. Dr. Belkin has considerable public speaking experience, and has the ability to put forth his thoughts in a clear and precise manner. I observed him a number of times presenting his research results. His presentations are very informative, well thought through and are easy to follow. I have not observed him in a classroom but I believe that he is a fine teacher. It is also clear that he works well in a team environment, willing to share his knowledge and expertise with students and colleagues. He has been supervising a number of students, and is involved in a number of university and professional conference committees, indicating that he is a good citizen. I feel confident that he possesses very high motivation and capabilities to continue his impressive research.

In summary, Dr. Belkin's research on novel optoelectronic and optomechanical devices, metamaterials, and photonic systems in mid-IR and THz frequency range is of world class quality and made a significant impact on the field. He stands out in terms of creativity and ability to actually carry out the research work. His research is visible, well regarded by the scientific community in the field, and in my opinion, he ranks at the very top within his peer group. I recommend his promotion to rank of Associate Professor with tenure in the Department of Electrical and Computer Engineering at The University of Texas at Austin.

Sincerely yours,

Y. Fainman

Yeshaiahu Fainman
Cymer and Distinguished Professor of ECE
Chair of Electrical and Computer Engineering Department

Jilda Gayle

From: Shaya Fainman <fainman@eng.ucsd.edu>
Sent: Sunday, August 11, 2013 11:37 AM
To: Bearden, Carole A
Cc: Tewfik, Ahmed H; Jilda Bolton (jildagayle@gmail.com)
Subject: Re: URGENT - Letter of reference for Dr. Mikhail Belkin
Attachments: Belkin 2013.pdf

sorry for the delay. Please find attached letter for Mikhail. shaya

On 8/5/2013 2:25 PM, Bearden, Carole A wrote:

> Dr. Fainman,
>
> This is a gentle reminder that your letter of reference for Dr. Belkin was due July 20th. Please let me know if you need further information.
>
> Many thanks,
>
> Carole
>
> **From:** Bearden, Carole A
> **Sent:** Wednesday, July 24, 2013 1:17 PM
> **To:** 'fainman@eng.ucsd.edu'
> **Cc:** Tewfik, Ahmed H (tewfik@austin.utexas.edu); Jilda Bolton (jildagayle@gmail.com)
> **Subject:** RE: Letter of reference for Dr. Mikhail Belkin
> **Importance:** High
>
> Dr. Fainman,
>
> This is a gentle reminder that your letter of reference for Dr. Belkin was due July 20th.
>
> Many thanks,
>
> Carole
>
> **From:** Bearden, Carole A
> **Sent:** Tuesday, June 18, 2013 3:55 PM
> **To:** 'fainman@eng.ucsd.edu'
> **Cc:** Tewfik, Ahmed H (tewfik@austin.utexas.edu); Jilda Bolton (jildagayle@gmail.com)
> **Subject:** Letter of reference for Dr. Mikhail Belkin
> **Importance:** High
>
> Dr. Fainman,
>
> Thank you for your support of Dr. Mikhail Belkin's promotion and agreeing to write a recommendation letter. Attached is a formal request for the letter with a website, logon and password to access his information as well as his CV.
>
> Best regards,

Prof. Yeshaiahu Fainman

Office: 3406 Engineering Building Unit 1

Mailing Address:

Department of Electrical and Computer Engineering

9500 Gilman Drive, Mail Code 0407

University of California, San Diego

La Jolla, CA 92093-0407

Email: yfainman@ucsd.edu

Phone: (858) 534-8909

Fax: Fax: (858) 534-1225

Ph. D., Technion-Israel Institute of Technology, 1983

M. Sc., Technion-Israel Institute of Technology, 1979

B. Sc., M. Sc Lvov Polytech. Inst., USSR, 1970

Research interests:

Applied optics and photonics; Optical Communications and Interconnections; Nanophotonics; Ultrafast Optics; Optical Information Processing Systems; Nonlinear and Diffractive Optics; Coherence Properties of Optical Field Scattered from a Moving Phase Screen; Photonic Networks; Optical

Professor Fainman joined the faculty at UCSD in July 1990 following a faculty appointment at the University of Michigan. Current research interests in his group include the investigation of artificial dielectric properties of nanostructures; polarization selective computer generated holograms and their applications for image processing, transparent photonic switching fabric and networks, and packaging optoelectronic devices and systems; programmable diffractive optical elements; 3-D holographic optical storage; diffractive optics with multifunctionality; optical information processing with femtosecond laser pulses; nonconventional 3-D imaging and displays; quantum cryptography for photonic network security and privacy.

Honors and Distinctions

• 2006 Brown Award for Quantum Computing

• 2006 Faculty Advisor for SPIE Student Chapter Recognition

• 2006 Lady Davis Fellowship

• 2004 Fellow of SPIE

• 2003 Fellow of the IEEE

• 1995 Fellow of the Optical Society of America

• 1995 Topical Editor of Optical Signal Processing and Imaging Science for

• 1982 Miriam and Aharon Gutvirt Prize, Technion, Haifa, Israel

• 1970 Honors Diploma, Lvov Polytechnic Institute, USSR

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institute of Quantum Electronics

Prof. Dr. Jérôme Faist
Quantum Optoelectronics Group
Wolfgang-Pauli-Strasse 16 / HPT F5
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Ahmed Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Dep. of Electrical and Computer Engineering
The University of Texas at Austin
ENS Room 236
2501 Speedway, C0803
Austin, Texas 78712-0240
USA

Zurich, July 5, 2013

Re: Promotion of Dr. Misha Belkin to the rank of Associate Professor with tenure

Dear Professor Tewfik.
Dear Members of the tenure committee

I know Dr. Belkin since his time as a Post-doc in Prof. Capasso's group mostly through his presentations at conferences and discussions with him. At that time, my group had grown a few epitaxial layers for the Capasso's group, reason for the few papers in which our both names appear together. I don't believe my judgment is in any way biased by that collaboration that remained very limited in scope and duration.

Ever since, I have closely followed his work and his progresses and I am truly impressed by his outstanding productivity and his capacity to expand into new areas. As I will show in the following, I strongly believe the EE department of the University of Texas at Austin made a very good choice hiring Prof. Belkin and that his recent achievements completely justify a tenured position.

In the following, I will concentrate on the work, realized during his Post-doc in Capasso's group and in his present position, in which he has made to my opinion his most important contributions and in which he has been clearly the key scientific driver. In summary, during a very short time, Prof. Belkin has made very important contributions to the improvement of THz QCLs, to MIR near-field spectroscopy as well as to the non-linear generation of short-wavelength mid-infrared light. He also produced some very nice work in plasmonics and metamaterials. However, by far his most important contribution is the invention and development of a completely original device where, for the first time, an intracavity generation of a single mode terahertz field is obtained in a monolithic, room temperature, electrically driven device of very compact dimensions.

In the following discussion, the reference numbering corresponds to the publication list of Prof. Belkin.

1. Mid-infrared, spectrally resolved near field spectroscopy.

Infrared microscopes operating in the mid-infrared and coupled to FTIR are standard equipment for analytical chemists. Such instruments allow a local chemical analysis of inhomogeneous samples and identify the various phases. However a very strong limitation of such instrument is the fact that its spatial resolution is restricted to the wavelength (at best) that, in the mid-infrared, is in the range of 10-20mm. Another very strong limitation is the very limited S/N of these instruments, as the brilliance of the blackbody light used for the illumination is naturally restricted. Using a quantum cascade laser as a source and an AFM detecting a thermo-mechanic expansion, Prof. Belkin has shown that very high spectral and spatial resolutions can be achieved together with short acquisition times. (Ref. 9. Optics Express)

2. Generation of short wavelength mid-IR using second harmonic generation.

(Ref. 11 (optics letters), 12 (Electronics letters) and 14 (Appl. Phys. Lett.) of the CV). Taking advantage of his very strong know-how in non-linear optics, Prof. Belkin has studied the generation of single mode mid-infrared light in the 2-3 mm wavelength band using the intracavity frequency doubling of 4-5mm QCL lasers. The idea is to extend the range of wavelength coverage to the region that is usually not accessible to quantum cascade lasers due to the limited conduction band discontinuity of the strain-compensated InGaAs/AlInAs material system. This work extended the initial concepts originally presented by Claire Gmachl (Princeton Univ) and Gottfried Strasser (TU Vienna) by using new design tricks that allowed him to achieve single mode, continuous wave operation for the first time. The fact of achieving continuous wave operation is very important for potential applications of this technology in spectroscopy.

3. Study and improvement of Terahertz quantum cascade lasers.

While in Harvard, Prof. Belkin has made a significant step in the improvement of high temperature operation of terahertz quantum cascade lasers by realizing that significantly lower losses could be achieved by the use of Cu-based waveguides. This translated in a maximum operation temperature of 172K, a record at the time (Ref. 15, Appl. Phys. Lett.). This innovation was copied by most other groups since then. He then continued to contribute to the understanding and improvement of the design of theses devices, through collaborations with key actors of the field (Refs. 30, 25, 17, 8).

4. Terahertz generation by intracavity non-linear mixing of a two-color quantum cascade laser.

This work is at present the most significant contribution of Prof. Belkin. The results have the potential to revolutionize the field of Terahertz by providing the first solid-state, room temperature compact source in the miliwatt power range. This device is the product of a very systematic work of Prof. Belkin that he initiated while he was still in F. Capasso's group. There, Dr. Belkin remarked that one of the best device architecture for high performance, the bound-to-continuum active region quantum cascade laser, did also possess a very high non-linear susceptibility that enabled it to operate as a non-linear mixer. In addition, the broad gain bandwidth of the active region easily accommodated a two-color emission separated by a terahertz frequency. Using this general arrangement, he has successively demonstrated the THz emission at low (Ref. 37, Nature Photonics) then room temperature (Ref. 29, Appl. Phys. Lett.). The following breakthrough was his realization that a Cerenkov phase matching could enable a much higher non-linear efficiency (Ref. 4, Appl. Phys. Lett.). Very recently, he has demonstrated that combining this architecture with a combination of distributed feedback and an external cavity laser enabled the generation of a very widely tunable, single mode source in the whole THz region. This result was published recently in Nature Communications (Ref. 1).

Compared to his peers, I find Prof. Belkin the strongest scientist in the field in his age group. Specifically, in breadth and impact of his research, he compares very favorably to Ben Williams (UCLA), Rafaele Colombelli (Univ. Paris Sud), Sushil Kumar (Leigh), and Nanfan Yu (Columbia).

Having attended a number of his talks, I can certify the pedagogical qualities of Prof. Belkin's presentations that always combined scientific accuracy with a very clear and accessible tone. I especially appreciated his care of never "over-simplifying" a topic and his providing a both compelling and interesting narrative.

As a conclusion, Prof. Belkin has made very important contributions in a very large range of fields of nano-optics, plasmonics, spectroscopy, laser physics and non-linear optics. I very strongly recommend the committee to award him the tenure, as I would do if he were in my University.

Yours,

Jerome Faist

Jilda Gayle

From: Jerome Faist <jerome.faist@phys.ethz.ch>
Sent: Monday, July 8, 2013 2:30 AM
To: Bearden, Carole A
Cc: Tewfik, Ahmed H; Jilda Bolton (jildagayle@gmail.com); Erna Hug
Subject: Re: Letter of reference for Dr. Mikhail Belkin
Attachments: Belkin_Reference.pdf; jerome_faist.vcf

On 6/18/13 10:56 PM, Bearden, Carole A wrote:
Dear Carole Bearden,
Please find attached my confidential review of Prof. Belkin's work. Let me know if the format is fine - probably you want a paper copy?
Yours
Jerome

> Dr. Faist,
>
> Thank you for your support of Dr. Mikhail Belkin's promotion and agreeing to write a recommendation letter. Attached is a formal request for the letter with a website, logon and password to access his information as well as his CV.
>
> Best regards,
>
> Carole Bearden
> Executive Assistant
> The University of Texas at Austin
> Electrical and Computer Engineering
> ENS Room 236
> 2501 Speedway, C0803
> Austin, Texas 78712-0240 USA
>
> "What starts here changes the world"

Jérôme Faist

Jérôme Faist was born in Switzerland and obtained his Ph.D. in Physics in 1989 from the Swiss Institute of Technology in Lausanne. He then worked successively at IBM Rueschlikon (89-91) and Bell Laboratories (91-97). He was nominated full professor in the physics institute of the University of Neuchâtel (1997) and then full professor in the ETH Zurich (2007).

His key contribution to the development of the quantum cascade laser was recognized by a number of awards that include the IEEE/LEOS William Streifer Award for Scientific Achievement and National Swiss Latsis Prize 2002.

In 1998, he also co-founded Alpes Lasers, a leading company selling quantum cascade lasers for spectroscopy application.

His present interests include the development of mid-infrared and terahertz quantum cascade lasers and frequency combs, the physics of strong light-matter coupling in metallic resonators and quantum dots intraband devices.

http://www.qoe.ethz.ch/

MIT EECS

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July 9, 2013

Dr. Ahmed Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Department of Electrical and Computer Engineering
The University of Texas at Austin
Austin, Texas 78712-0240
Email: tewfik@austin.utexas.edu

Dear Professor Tewfik:

In response to your request of June 18, 2013, I am writing to provide a supporting letter for the promotion case of Dr. Mikhail Belkin to the rank of Associate Professor with tenure.

I have known Dr. Belkin since 2004 when he joined Prof. Capasso's group at Harvard University as a postdoc. His postdoctoral research mainly focused on the development of THz sources based on quantum-cascade structures. This happens to be my own main research area, thus I have followed his work closely since his postdoctoral years. I will mostly comment on his contribution in this area, first the development of THz quantum cascade lasers and then the development of THz sources based on intracavity different-frequency generation (DFG).

Terahertz (1-10 THz) frequencies are among the most underdeveloped electromagnetic spectra, even though their potential applications are promising in detection of chemical and biological agents, imaging for medical and security applications, astrophysics, remote atmospheric sensing and monitoring, noninvasive inspection for quality control, and high-bandwidth communications. This underdevelopment is primarily due to the lack of coherent and powerful solid-state THz sources. This is because the THz frequency falls between two other frequency ranges in which conventional semiconductor devices have been well developed. One is the microwave and millimeter-wave frequency range, and the other is the near-infrared and optical frequency range. Semiconductor electronic devices that utilize conduction electrons (such as transistors) are limited by the transit time and parasitic *RC* time constants to below 1 THz. Conventional semiconductor photonic devices based on interband transitions (such as bipolar laser diodes), however, are limited to frequencies higher than those corresponding to the semiconductor energy gap, which is higher than 10 THz even for narrow-gap lead-salt materials. Thus, the frequency range of 1-10 THz is inaccessible for conventional semiconductor devices. Semiconductor quantum wells are human-made quantum-mechanical systems in which the energy levels can be designed and engineered to be any value. Consequently, photonic sources based on intersubband transitions hold great promise to fill in this so-called THz gap. In 2001, a quantum cascade laser operating in this frequency range was developed by a European team, and the progress since then has been impressive.

Dr. Belkin started his development of THz sources at Harvard. He came from a background in nonlinear optics, graduating from Prof. Y. R. Shen's group at U. C. Berkeley, who

is widely considered a leader in the field. Dr. Belkin initially worked on THz quantum cascade lasers (QCLs), largely following the work in my group on THz QCLs based on resonant-phonon gain medium and metal-metal waveguides. Remarkably, he was an exceptionally quick learner and produced laser devices with record performance. By using low-loss metal-metal waveguides, he established a new record of operating temperature of 178 K, which stood for more than a year. This accomplishment established Dr. Belkin as a player in the field. His greatest contribution, in my opinion, is the development of room-temperature and broadly tunable THz sources based on intracavity DFG.

Similar to the history of laser development, in which nonlinear optics was developed shortly after the invention of lasers, the flexibility of design and fabricating suitable quantum-well structures also allows one to engineer structures with large nonlinear optical coefficients at desired frequencies. Coupled with powerful QCLs at mid-infrared, a subfield of nonlinear optics based on intracavity generation was born. These developments, based on the unique feature of intersubband transition in artificial quantum systems that can be customer designed and engineered, has broadened the scope of QCL field, both in physics and applications. Dr. Belkin has been a major player in this subfield, for which his previous background in nonlinear optics at U. C. Berkeley is highly beneficial. Along with his colleagues at Harvard, he is the first to demonstrate room-temperature DFG THz generation based on a careful design of quantum cascade structures to enhance the second-order nonlinearity. The initial work did not yield sufficient power for practical applications, but it has firmly established the operation principle. Since joining the faculty at U. T. Austin, his group has made significant progress in developing potential useful THz sources based on DFG. The most important conceptual development from his group is to use Čerenkov instead of collinear phase matching condition to significantly increase the generated THz power (Appl. Phys. Lett. **100**, 251104 (2012)). Free carrier absorption is strong at the long wavelengths of THz and it is scaled as λ^2. On the other hand, the mid-infrared QCLs that generate the DFG signals are doped at a high level, resulting in an absorption length of ~100μm at THz. Consequently, only the generated THz signals from ~100 μm at the end of laser cavity can couple out to the free space, producing a weak output. The cleverness of this development is to take advantage of larger value of $\vec{k}$ -vector at THz than at infrared and couple out of the generated THz signal at an angle that is determined by Čerenkov phase-matching condition. In this way, THz signal generated over a much greater length can be coupled out of the cavity, yielding much greater power levels. Based on this scheme, Dr. Belkin's group has developed a room-temperature THz source with ~0.1 mW and a broad tuning range of several THz (Nature Comm. **4**, 2021 (2013)). This is a significant development which could lead to compact THz sources with broad frequency coverage.

I have also followed Dr. Belkin's work in other areas, although with a lesser degree. One development that I found quite attractive is his work on infrared spectroscopy at nanometer scale (Optics Express **19**, 19942 (2011)). This tool could be useful in bio-related studies. His work on plasmonics and metamaterial structures is also of good quality, showing his versatility in research. Going through his CV, he has certainly raised adequate funding to pursue research in several areas. It is remarkable that he has established fruitful collaborations, both within the U. S. and internationally, to assemble the required resource to carry out research of his original ideas. I have never seen Dr. Belkin teaching in a classroom, but I have observed him giving invited talks during numerous occasions. His presentations are always clear and polished. I can imagine that he is an effective teacher in both undergraduate and graduate courses.

In summary, I believe that Dr. Belkin has made a successful career at U. T. Austin. His accomplishment and status are comparable to other successful young faculty members at this stage, most notably Prof. Benjamin Williams who just got tenure at UCLA. Following his trajectory, I believe his highly productive research will continue in foreseeable future and I support his tenure promotion without any reservation. Please let me know if I could provide any further information.

Sincerely yours,

Qing Hu

Professor of Electrical Engineering
Fellow of AAAS, APS, IEEE, OSA
www.rle.mit.edu/thz/people_hu.htm

Jilda Gayle

From: Qing Hu <qhu@MIT.EDU>
Sent: Tuesday, July 9, 2013 7:03 PM
To: Bearden, Carole A
Cc: Tewfik, Ahmed H; Jilda Bolton (jildagayle@gmail.com)
Subject: Re: Letter of reference for Dr. Mikhail Belkin
Attachments: Belkin-7-2013.pdf

Importance: High

Carole,

Here is my letter for Dr. Belkin's case.

Best,
Q. Hu

On Jun 18, 2013, at 4:58 PM, "Bearden, Carole A" <cjp@mail.utexas.edu> wrote:

Dr. Hu,

Thank you for your support of Dr. Mikhail Belkin?s promotion and agreeing to write a recommendation letter. Attached is a formal request for the letter with a website, logon and password to access his information as well as his CV.

Best regards,

Carole Bearden
Executive Assistant
The University of Texas at Austin
Electrical and Computer Engineering
ENS Room 236
2501 Speedway, C0803
Austin, Texas 78712-0240 USA

<Belkin-Hu.pdf><Belkin CSE resume.pdf>

Qing Hu
Professor of Electrical Engineering
qhu@mit.edu | RLE Bio

Professor Qing Hu is a principal investigator in the Research Laboratory of Electronics (RLE) at the Massachusetts Institute of Technology (MIT). He received his B.A. from Lanzhow University in 1981 and his Ph.D. in physics from Harvard University in 1987. From 1987 to 1989, he was a postdoctoral associate at University of California, Berkeley. He joined the MIT faculty in 1990 in the Department of Electrical Engineering and Computer Science. He was promoted to full professor in 2002.

Professor Hu has made significant contributions to physics and device applications over a broad electromagnetic spectrum from millimeter wave, THz, to infrared frequencies. Among those contributions, the most distinctive is his development of high-performance terahertz (THz) quantum cascade lasers (QCLs). Now this breakthrough has already found applications in heterodyne receiver technology and real-time THz imaging, which was also pioneered by his group. He is a Fellow of the Optical Society of America (OSA), a Fellow of the American Physical Society (APS), a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), and a Fellow of the American Association for the Advancement of Science (AAAS). He is the recipient of 2012 IEEE Photonics Society William Streifer Scientific Achievement Award. He has been an Associate Editor of Applied Physics Letters since 2006, and was the co-chair of 2006 International Workshop on Quantum Cascade Lasers.

Professor Hu's current research interests focus on the development of high-temperature, high-power, high beam-quality, and broadly tunable THz QCLs; THz amplifiers; ultrafast time- and phase-resolved study of dynamics in quantum structures; sensing and real-time imaging THz systems for a variety of applications including remote sensing, biomedical imaging, and security.

Code 5604
Naval Research Laboratory
Washington DC 20375

July 20, 2013

Dr. Ahmed Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Department of Electrical and Computer Engineering
The University of Texas at Austin
Austin TX 78712-0240

Dear Dr. Tewfik,

You requested that I assess the scholarly contributions of Dr. Mikhail Belkin, in connection with his nomination for promotion to the rank of Associate Professor in your Department. Although I have had limited personal contact with Dr. Belkin and do not feel that I know him well, based on casual contact at conferences, his publications that have been of ongoing interest to me, his reputation, and the materials you sent, I feel that he is extremely well qualified for a tenured faculty position at a major research university.

By way of introduction, I am the Navy Senior Scientist for Quantum Electronics (ST). I am also Acting Head of the Quantum Optoelectronics Section in the Optical Sciences Division of the Naval Research Laboratory (NRL), which employs 9 Ph.D. physicists and electrical engineers. I am a Fellow of the American Physical Society, the Optical Society of America, the Institute of Electrical and Electronics Engineers, the Institute of Physics, and SPIE. For over 35 years at NRL I have carried out a wide variety of basic and applied investigations of optoelectronic materials and devices, for both military and commercial applications. Current development projects include new classes of semiconductor lasers and detectors for the infrared. This research has produced over 340 refereed journal articles that have been cited more than 13,000 times (H-Index = 47), 28 patents (7 of them licensed), and more than 140 invited and plenary conference presentations.

I don't recall when I first met Dr. Belkin, and according to my files we have never exchanged e-mail. However, I have closely followed his publications on quantum cascade lasers (QCLs) ever since he joined Prof. Capasso's group at Harvard in 2004. He has co-authored important papers on a wide variety of topics in this area, a large fraction of these as first author. These include major investigations of second harmonic and difference frequency generation in QCLs (especially as a means for achieving high performance at THz wavelengths), double-metal-waveguide surface emitting THz QCLs, high-operating-temperature THz QCLs, photonic crystal QCLs employing optofluidic cooling, chaotic cavities producing single-mode output, plasmonic-antenna QCLs, metamaterial optical polarizers, widely-tunable QCL arrays, pioneering QCL groth by MOCVD, mode-locked QCLs, and beam-combining of arrays. This very impressive body of work has appeared in the leading optoelectronics journals, including *Nature Photonics*. Furthermore, while his research at Harvard clearly benefited from Prof.

Capasso's guidance, Dr. Belkin's high productivity of important work has continued since he became an Assistant Professor at U. Texas in 2008. For example, just since 2012 he has published two papers in *Nature Communications*. Eleven of his publications have already been cited more than 40 times (up to 112 in one case, according to ISI). Of these many key contributions, it would be difficult for me to single out one or two that are the *most* significant.

While it seems that he has not advised very many students thus far, according to his CV he has successfully marketed a large number of research proposals. His level of involvement in conference Program Committees and Co-Chairing a conference is well ahead of what one would normally expect for his career stage. He also appears to be involved in several committees at the university level. I naturally have no first-hand knowledge of his teaching abilities.

In short, I feel that Dr. Belkin is extremely well qualified for the Associate Professorship position in your Department, and feel that he would rank among the top 5% of his peers. I also see no reason that his high level of productivity and impact should not continue into the future. Please let me know if you need any further input from me.

Sincerely,

Jerry R. Meyer

Jerry R. Meyer
Head, Quantum Optoelectronics Section
(202) 767-3276; jerry.meyer@nrl.navy.mil

Jilda Gayle

From: Jerry Meyer <jerry.meyer@nrl.navy.mil>
Sent: Saturday, July 20, 2013 10:28 AM
To: Bearden, Carole A
Cc: Tewfik, Ahmed H; Jilda Bolton (jildagayle@gmail.com)
Subject: Re: Letter of Reference for Dr. Mikhail Belkin
Attachments: Letter.doc

Carole & Ahmed,

My letter of recommendation is attached. Do you need for me to send a signed hard copy? Or I can possibly convert it to pdf and sign electronically?
*****
On 7/3/2013 11:45 AM, Bearden, Carole A wrote:

> Dr. Meyer,
>
> Thank you for your support of Dr. Mikhail Belkin's promotion and agreeing to write a recommendation letter. Attached is a formal request for the letter with a website, logon and password to access his information as well as his CV.
>
> Best regards,
>
> Carole Bearden
> Executive Assistant
> The University of Texas at Austin
> Electrical and Computer Engineering
> ENS Room 236
> 2501 Speedway, C0803
> Austin, Texas 78712-0240 USA
>
> "What starts here changes the world"

Attachment Converted: "C:\Sisyphus\Incoming\Belkin-Meyer.pdf" Attachment Converted: "C:\Sisyphus\Incoming\Belkin CSE resume.pdf"

Jerry Meyer, U.S.
...
Jerry Meyer is the team leader and head of the NRL Quantum Optoelectronics section. Dr. Meyer has produced over 170 refereed journal articles, 11 book chapters, 16 patents and 60 invited presentations in the past ten years. His awards include: five Alan Berman Research Publications Awards, an NRL Distinguished Contribution Allowance Award, two Special Act awards, a Federal Laboratory Consortium Award for Excellence in Technology Transfer, and a Technology Transfer Royalty Award. He is a Fellow of the American Physical Society (APS) and the Optical Society of America (OSA), a senior member of the Institute of Electrical and Electronics Engineers (IEEE), and a member of the Materials Research Society and the International Society Optical Engineers (SPIE). Dr. Meyer received his B.S. degree in engineering physics from the University of Tennessee, in 1972. He earned his M.S. degree and Ph.D. in physics from Brown University, in 1974 and 1977 respectively. He served as an NRC Research Associate at NRL from 1977 to 1979. Dr. Meyer joined NRL's Optical Sciences Division in 1980, as a research physicist conducting investigations of optical and transport properties of narrow-gap IR detector materials.

COLLEGE OF SCIENCE

INSTITUTE FOR QUANTUM STUDIES

Marlan O. Scully
Director
Burgess Distinguished Professor
TEES Distinguished Research Professor

TEXAS A&M UNIVERSITY

Dr. Ahmed Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Department of Electrical and Computer Engineering
The University of Texas at Austin
Austin, Texas 78712-0240

June 21, 2013

Dear Dr. Tewfik and the members of tenure and promotion committee,

It is my great pleasure to write a letter of support for Dr. Mikhail (Misha) Belkin's tenure promotion case.

I first met Misha in Spring of 2008 when I was visiting my friend Prof. Federico Capasso at Harvard University. Misha was finishing up his postdoctoral tenure in Federico's group and was in the process of interviewing for faculty positions. We had a lengthy conversation with Misha over lunch one day and I was impressed by his knowledge of nonlinear optics and his ideas on developing quantum cascade laser sources and photonic technology for chemical sensing and imaging in mid- and far-infrared. In fact, I was so excited with his knowledge and ideas, that I have called my colleagues at Physics Department of the Texas A&M University and persuaded them to contact Misha and invite him for an interview as soon as possible. Unfortunately, the timing of our meeting was too late and Misha has already been in the final stages of negotiating with UT Austin and other schools by the time he came to Texas A&M for an interview.

I could follow Misha's research progress closely after he joined the ECE Department of UT Austin as he was a regular invited speaker at the Physics of Quantum Electronics (PQE) Conference that I and my colleagues organize in Snowbird, UT in January of every year. Misha also comes occasionally to Texas A&M University where he had a collaboration with Prof. Alexey Belyanin in our department. I have last seen him in January this year when he gave an excellent 45 minute keynote talk on doing nanoscale infrared vibrational spectroscopy by detecting molecular forces at the workshop that I and my colleagues organized in the Institute for Quantum Science and Engineering at Texas A&M. This work, which was conceived and implemented by Misha and his group in UT Austin, makes a major impact on nanoscale spectroscopy. His method produces high-quality mid-infrared spectra in ambient conditions with the highest sensitivity demonstrated to date by any means while relying on in extremely simple experimental setup. The spectroscopy is based on detecting minute mechanical forces that the molecules exert on the atomic force microscope tip upon optical vibrational excitation. Previously, nanoscale spectroscopy in mid-infrared was performed by scattering near-field optical microscopy technique which detected minute amounts of scattered light by molecules and is based on an extremely complex optical setup that requires constant maintenance and adjustments. Such a technique could not spread beyond a few dedicated research groups in Physics departments. Misha's approach, in contrast, results in very simple setup with minimum maintenance and his findings generate a lot of interest in chemical and biological communities. Needless to say that Misha was invited to a number of venues to present his progress in this area. I was glad to learn from Misha's research statement that he is now working on commercializing this technique

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with the help of a $1M Phase II Small Business Technology Transfer grant from the Department of Energy.

Another breakthrough contribution that Misha has made at the University of Texas is the development of the first mass-producible semiconductor laser sources of terahertz radiation. His most recent work, published in one of the top academic journals, Nature Communications, has demonstrated that these devices not only operate at room temperature but can also be broadly-tunable in nearly entire 1-5 THz frequency range. It is remarkable these lasers appear very simple to the users, virtually undistinguishable from diode lasers, while having extremely complex inner workings. The THz radiation is generated in a nonlinear process of difference-frequency generation and the laser active region is quantum-engineered to possess both laser gain at two mid-infrared frequencies and giant optical nonlinearity for difference-frequency THz generation. The waveguide is equally complex, based on the process of Cherenkov emission by the nonlinear polarization wave that propagates faster than the speed of THz light in the laser material. There results have established Misha's as the leading group in the area of terahertz quantum cascade laser sources and terahertz photonics in general. It is not surprising that Misha was called to give an invited talk on his latest THz sources at the most selective and most recognized photonics conference CLEO Conference in June this year.

From Misha's research statement, I also see that he has made significant contributions to the field of metamaterials and plasmonics and that he plans to explore this area further. I agree with his assessment that plasmonic systems are particularly promising for operation at mid-infrared and THz frequencies, where metal losses are manageable and high optical field confinement provided by plasmons is highly desired. Misha's demonstration that long-range surface palsmon polariton modes in thin metal films can be used to create broadly-tunable optical filters may lead to the development of compact broadly-tunable laser sources and compact spectrometers for chemical analysis. In collaboration with Prof. Andrea Alu, Misha has also demonstrated a novel kind of circular optical polarizer based on plamosnic mode coupling in 'twisted metamaterials'. This work have shown that 3-dimensional plasmonic effects, such as circular polarizaion selectivity, may be obtained using layered plasmonic nanostructures in which optical modes in nanoinclusions in adjacent layers are electromagnetically coupled. Both of these contributions were published in top-quality journals: Optics Letters and Nature Communications, respectively.

A new research area that is opening up at the moment is plasmonic effects of graphene and other low-dimensional semiconductor materials, which are expected to have extremely low-loss and gate-tunable plasmonic characteristics in mid-infrared and THz frequencies but not at shorter wavelengths. I am excited to see that Misha is planning on exploring this subject and I expect to hear great results in this new area from his group.

Misha Belkin has been publishing in the most selective journals in his research area, such as Nature Communications, Optics Letters, Applied Physics Letters, and Optics Express. His publication record and the number of invited talks he has given at the major conferences is outstanding. So is his record of attracting external funds. Remarkably, his funding sources are extremely diverse, which indicates the breadth of the impact his research is making.

In a short time Misha was able to build a highly-successful research group and, in my opinion, he is now the innovative and most accomplished scientist among his peers in the area of mid-infrared and THz photonics. I also consider Misha to be one of the most successful young scientists in photonics area in general. I would be delighted to have him as a tenured colleague in my department. The University of Texas at Austin is lucky to have him and should make every effort to keep Misha as its faculty. If I could hire him away from you, I would!

Sincerely,

Marlan O. Scully

Jilda Gayle

From: Marlan Scully <scully@tamu.edu>
Sent: Monday, June 24, 2013 8:41 AM
To: 'Bearden, Carole A'; scully@mail.physics.tamu.edu
Cc: 'Tewfik, Ahmed H'; 'Jilda Bolton'
Subject: RE: Letter of Reference for Dr. Mikhail Belkin
Attachments: Belkin.pdf

Dear Dr. Tewfik,

Please find the requested letter attached.

Best regards,
Marlan

Marlan Scully, Director
Institute for Quantum Science and Engineering
Texas A&M University
4242 TAMU
College Station, Texas 77843-4242
Phone: 979.862.2333 || Fax: 979.458.1235

From: Bearden, Carole A [mailto:cjjp@mail.utexas.edu]
Sent: Tuesday, June 18, 2013 3:00 PM
To: scully@mail.physics.tamu.edu
Cc: Tewfik, Ahmed H; Jilda Bolton (jildagayle@gmail.com)
Subject: Letter of Reference for Dr. Mikhail Belkin
Importance: High

Dr. Scully,

Thank you for your support of Dr. Mikhail Belkin's promotion and agreeing to write a recommendation letter. Attached is a formal request for the letter with a website, logon and password to access his information as well as his CV.

Best regards,

Carole Bearden
Executive Assistant
The University of Texas at Austin
Electrical and Computer Engineering
ENS Room 236
2501 Speedway, C0803
Austin, Texas 78712-0240 USA

BRIEF BIOGRAPHICAL SUMMARY

Marlan O. Scully (Texas A&M and Princeton) is a quantum optics pioneer. His work includes the first quantum theory of the laser with Lamb, the first demonstrations of lasing without inversion, the first demonstration of ultraslow light in hot gases, and the use of quantum coherence to detect anthrax in real time. Furthermore Scully's work on quantum coherence and correlation effects has shed new light on the foundations of quantum mechanics, e.g., the quantum eraser.

He has been elected to the: National Academy of Sciences, American Academy of Arts and Sciences, Academia Europaea, and Max Planck Society; has numerous awards including the: APS Schawlow prize, OSA Townes Award, IEEE Quantum Electronics Award, Franklin Institute's Elliott Cresson Medal, OSA Lomb Medal, and Humboldt Senior Faculty Prize. More recently he was named Harvard Loeb Lecturer, received an honorary doctorate from Universität Ulm, and was awarded the OSA/DPG Herbert Walther Award. Most recently, he was awarded the OSA Frederic Ives Medal which recognizes overall distinction in optics and is the highest award of the Society.

Prof. Carlo Sirtori
Université Paris-Diderot-Paris 7
Laboratoire MPQ – UMR 7162
75205 Paris cedex 13

Paris, 19th July 2013

Object: Letter of reference for Dr Mikhail Belkin

TO WHOM IT MAY CONCERN

This is a letter of reference for Dr Mikhail Belkin in connection with his application for associate professor position and tenure at the University of Texas at Austin.

I write as one who has known Dr Mikhail Belkin for already few years. I have had a full opportunity to form an opinion on his research skills and his capacity to interact successfully with colleagues and in the following I shall detail my opinion on these issues.

I met Dr Belkin few years ago at a conference in Switzerland while he was just at the end of his post-doc in the group of Professor F. Capasso. I was impressed by his clarity while he was presenting to me his recent results. Our scientific discussion then continued on less technical issues and I had the pleasure to observe his capacity of putting his research ideas on long term perspectives. Since then I have been regularly in contact with him also because we share many common research interests, in particular nonlinear optics and quantum cascade lasers. I can surely affirm that Dr Belkin is a highly motivated researcher who is thoroughly involved in physics and in particular quantum devices. What I enjoy with him is his pragmatic interest for "what works". For him quantum phenomena are not a philosophical abstraction but the means to extract functionalities from the matter and conceive novel devices.

Among his most noteworthy achievement I would definitely mention the THz generation via intracavity difference-frequency generation in a two-color quantum cascade laser. For the past five years he has remained fully focused on this very promising THz source which is one of the most interesting semiconductor devices for producing THz radiation at room temperature. Such constancy has induced a very fruitful synergy between the engineering of the device and the understanding of the underlying physical phenomena. What

Laboratoire Matériaux et Phénomènes Quantiques
UMR 7162 CNRS / Université Paris Diderot - Paris 7, Bâtiment Condorcet, case 7021, 75205 Paris cedex 13
carlo.sirtori@univ-paris-diderot.fr tél. 01 57 27 62 44 fax. 01 57 27 62 41
www.mpq.univ-paris-diderot.fr

has really impressed me recently is his work to improve the extraction of the THz radiation by exploiting the Čerenkov difference-frequency scheme. Finally, it is important to mention that this is not the only research work of the past few years. Other interesting activities, in particular in the field of optoelectronics, have also being developed.

In light of the results just described I have no doubt that Dr Belkin ranks among the top ten percent researchers in his field, as also testified by his many awards and grants among which one must mention the Norman Hackerman Advanced Research Program Award for Early Career Investigators.

I would like to add that his remarkable expertise in the mid-infrared spectral domain has already given him the possibility to extend his research in new directions and in particular that of mid-infrared spectroscopy at the molecular level. This project has a strategic potential for spatially resolved molecular spectroscopy and a concrete potential for applications. I have full confidence in his capacity to bring significant contributions in the competitive field of near field scattering spectroscopy.

Throughout his research career Dr Belkin has already published in the best peer reviewed journals more than 50 papers and has also given more than 20 invited talks and numerous seminars and lectures throughout the world. This last point allows me to underline another unique characteristic of the personality of Dr Belkin, which is his ability to establish long standing productive collaborations with the best research groups in his domains of interest.

In summary, I believe that Dr Belkin can be a leader in the field of optoelectronics quantum devices and a very good teacher. He will definitely be an asset for the University of Texas at Austin.

I hope that these comments on Dr Belkin will be helpful to your final decision. Please feel free to contact me again.

Sincerely yours,

Carlo Sirtori
Professor University Paris-Diderot
Director MPQ laboratories
Member of "Institut Universitaire de France"

MPQ
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carlo.sirtori@univ-paris-diderot.fr tél. 01 57 27 62 44 fax. 01 57 27 62 41
www.mpq.univ-paris-diderot.fr

Jilda Gayle

From: Bearden, Carole A <cjjp@mail.utexas.edu>
Sent: Wednesday, July 24, 2013 5:13 PM
To: Jilda Bolton (jildagayle@gmail.com)
Subject: FW: Recommendation letter for Misha Belkin
Attachments: MBelkin_2013.docx

FYI

-----Original Message-----
From: Carlo Sirtori [mailto:carlo.sirtori@univ-paris-diderot.fr]
Sent: Sunday, July 21, 2013 10:34 AM
To: Tewfik, Ahmed H
Cc: Bearden, Carole A
Subject: Re: Recommendation letter for Misha Belkin

Dear Ahmed,
please find attached the letter of recommendation for Misha Belkin.
I sent it already to Carole Bearden on Friday, but not knowing exactly to whom I was supposed to send it, I send it also to you. Note that the attached version is the "final version", in the sense that after rereading the letter this afternoon, I felt like changing a couple of sentences. So please consider the attached letter as the right one.

Best regards,
Carlo

Le 15/06/2013 05:32, Tewfik, Ahmed H a écrit :
> Thank you Carlo!
>
> regards
>
> Ahmed
>
>
>
> _____
>
> Ahmed Tewfik
> Cockrell Family Regents Chair in Engineering Chairman, Department of
> Electrical and Computer Engineering The University of Texas at Austin
>
> ENS Room 236
> 2501 Speedway, C0803
>
> Austin, Texas 78712-0240 USA
>
>

Prof. Carlo Sirtori. After his doctorate degree in physics at the University of Milan in 1990, he joined Bell Labs where he started his research carrier on quantum devices. During the 7 years spent at Bell Labs, he made important contributions such as the invention and the development of the QCL. In 1997, he left Bell Labs to join the LCR of Thomson-CSF (currently Thales Research & Technology, TRT). In 2000 he was named head of the "Semiconductor Laser Group" and responsible of the clean room at TRT for the development of semiconductor lasers in the near- and mid-IR. During these years his research focused on the demonstration of innovating devices such as the first quantum cascade laser in the GaAs/AlGaAs material system, the first Sb-based QCLs and the development of plasmonic waveguides for GaAs. In 2002, he was appointed Professor at Paris Diderot University. Prof. Sirtori has authored >160 articles in peer-reviewed journals, given > 50 invited talks at international conferences, and received several awards such as the Fresnel Prize (EPS). In 2006 he was rewarded by the "quantum devices award" sponsored by the APS.

RICE

Frank K. Tittel

J.S. ABERCROMBIE PROFESSOR
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

August 8, 2013

Dr. Ahmed Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Department of Electrical and Computer Engineering
The University of Texas at Austin
Austin, TX 78712-0240

Dear Prof. Tewfik:

In response to your recent letter dated July 3, 2013 I am pleased to provide you with my enthusiastic support for the promotion of Prof. Mikhail Belkin to Associate Professor in your Department of Electrical and Computer Engineering at The University of Texas at Austin.

I have known Dr. Belkin for the past 7 years. I first met him at a conference while he was a postdoctoral researcher in the group of Prof. Federico Capasso in the School of Engineering and Applied Sciences of Harvard University. At that time I was collaborating with Prof. Capasso's group on mid-infrared gas sensing using quantum cascade lasers (QCLs) and although Dr. Belkin's research in the Capasso group was related to THz technology and liquid sensing we never worked together. I immediately noticed the bright new postdoc in the Capasso group, Dr Belkin. My interaction with Dr. Belkin continues to this date as we regularly meet at conferences (most recently in June this year at the 2013 CLEO conference in San Jose and before that in February at 2013 US-UK workshop on Mid-IR and THz technology in Edinburgh) and attended each other's talks,

My group has been pioneering the application of QCLs for gas spectroscopy since 2000 and I follow new developments in QCL design and performance as well as their applications. Dr. Belkin's research group at UT Austin has made two major and independent contributions to this field, in addition to other contributions to photonics devices and metamaterials research that are outside of my expertise.

Dr. Belkin's first major contribution is the development of the terahertz quantum cascade lasers that can operate at room temperature. These devices can also be mass-produced at existing telecommunication laser foundries. Previously, QCLs could only operate at room-temperature in the mid-infrared spectral range and their operation in the 1-5 THz range was limited to cryogenic temperatures. Through highly-innovative design based on nonlinear frequency mixing in mid-infrared QCLs Dr. Belkin has succeeded to produce lasers that can

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generate output powers at almost the milliwatt-level in the THz spectral range and operate at room temperature. These devices are also widely-tunable which is extremely important for spectroscopic applications. This work has been published in "Nature Communications" earlier this year and it will have a profound impact on sensing and imaging applications for years to come. To emphasize the importance of this development, I mention that my colleague at Rice University Prof. Daniel Mittleman, an expert in THz technology, has just submitted a pre-proposal for creating the NSF Engineering Research Center 'Center for Applied Terahertz Systems (CATS)' and Dr. Belkin has been invited (and accepted) to lead the 'THz sources and detectors' thrust for this proposed center.

Dr. Belkin's second significant contribution is the development of novel ultra-sensitive sub-wavelength microscopy in the mid-infrared spectral range based on sample photoexpansion induced by pulses of light from quantum cascade lasers. Dr. Belkin has recently demonstrated that he can achieve sensitivity for sample imaging that is higher than that achieved by current state-of-the-art 'near-field scanning optical microscopy' techniques based on highly-complex optical configurations.. In contrast, Dr. Belkin's approach results in a relatively simple platform which can be maintained outside of optics laboratories. His approach is now being commercialized and I also know that at least three laboratories: one at NIST (Gaithersburg) , one at the University of Rome Sapienza, and one at the Technical University of Vienna are now reproducing Dr. Belkin's innovative, mid-infrared microscopy architecture for their research.

Needless to say that these contributions have attracted attention of the engineering and scientific community and Dr. Belkin has presented a large number of invited talks at numerous different conferences and meetings, including the most selective conferences in photonics such as the CLEO and Photonics West conferences, and also to conferences outside of his immediate specialization such as the Canadian Chemistry Conference and SCIX (a conference organized by the Federation of Analytical Chemistry and Spectroscopy Societies).

Personally, I have attended a number of conferences at which Dr. Belkin presented invited talks and that includes his most recent presentation at Photonics West 2013 and CLEO 2013 conferences. His presentations were unquestionably outstanding in terms of technical content, his enthusiasm for the field and in terms of style, which kept the audience engaged. In September 2013 Prof. Belkin will be a Co-Chair of the prestigious 12th International Conference on Intersubband Transitions in Quantum Wells".

In addition to his scientific strengths, Dr. Belkin has demonstrated his ability to be an excellent teacher and mentor of undergraduate and graduate students as well as a post-doctoral fellow at UT Austin

Let me summarize by stating that Dr. Belkin has distinguished himself as an extremely talented and creative scientist and engineer in photonics science and technology. He has proven his ability of conducting independent experimental and theoretical scholarly research. His national and international recognition by his peers is underscored by his timely and innovative research, which has resulted in numerous publications and conference presentations as documented in his biography.

I enthusiastically recommend Dr. Belkin without reservation for promotion to the rank of Associate Professor in the Department of Electrical Engineering at the University of Texas. Mikhail Belkin is an exceptionately dedicated intellectual leader and is making truly

significant and creative contributions to science and technology that bring distinction and visibility to your department. Therefore I have no doubt that Dr. Belkin meets and exceeds the very high standards that The University of Texas at Austin has for such an appointment and that his future research will continue to have a very significant impact nationally and internationally. If you have any further questions please do not hesitate to contact me.

Yours sincerely,

Hans K. Tittel

Jilda Gayle

From: Frank K. Tittel <fkt@rice.edu>
Sent: Wednesday, August 7, 2013 9:32 PM
To: 'Tewfik, Ahmed H'
Cc: 'Bearden, Carole A'; 'Jilda Bolton'
Subject: RE: Letter of Reference for Dr. Mikhail Belkin/from fkt Aug 7 2013
Attachments: Reference letter for Dr M Belkin UTA Aug 7 2013 revised.doc

Dear Ahmed:

Many thanks for your thoughtful e-mail

I just notice that I had a redundant "a" in the third sentence of my second paragraph. Please accept my revised letter
Best regards

Frank

From: Tewfik, Ahmed H [mailto:tewfik@austin.utexas.edu]
Sent: Wednesday, August 07, 2013 4:38 PM
To: Frank K. Tittel
Cc: Bearden, Carole A; Jilda Bolton
Subject: Re: Letter of Reference for Dr. Mikhail Belkin

Many thanks Frank!

We greatly appreciate your support!

regards
Ahmed

Ahmed Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Department of Electrical and Computer Engineering
The University of Texas at Austin
ENS Room 236
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On Aug 7, 2013, at 11:33 PM, "Frank K. Tittel" <fkt@rice.edu> wrote:

> Dear Carole and Dr. Tewfik::
>
> I apologize for the delay of my letter of reference for Dr. Mikhail Belkin
>
> With best regards,

Frank K. Tittel

J.S. Abercrombie Professor in Electrical and Computer Engineering
Rice University
fkt@ece.rice.edu

Quantum Electronics, Laser Spectroscopy, Nonlinear Optics, Applications in Trace Gas Detection, Environmental Monitoring, Industrial Process Control and Biomedical Optics

B.A. (1955) Oxford University
M.A. (1959) Oxford University
Ph.D. (1959) Oxford University

Professor Frank Tittel has been involved in many innovative developments in quantum electronics and laser technology since the discovery of the laser in 1960, with applications ranging from laser spectroscopy to environmental monitoring. Current research activities by Professor Tittel, together with Professor Robert Curl of the Chemistry Department, have led to the development of several advanced, state of the art, computerized laser spectrometers. The most recent designs utilize telecommunications technology and novel quantum cascade lasers to achieve compact, robust instrumentation that can be deployed for field applications, such as at NASA's Johnson Space Center related to air and water quality issues relevant to the International Space Station, by the Environmental Protection Agency for urban formaldehyde monitoring, and by the National Institute of Health for non-invasive NO and CO detection in biomedical systems. Long-term, sensitive, selective, and real time trace gas monitoring and quantification has been realized for trace gas concentrations ranging from the part per million to the part per trillion levels in ambient air using laser absorption spectroscopy with fiber amplified diode laser and quantum cascade laser based gas sensors.

For a more detailed look at the specific projects addressed by Professor Tittel's research group, view the **Laser Science Group** homepage.

Professor Tittel is a Fellow of the Institute of Electrical and Electronic Engineers, the Optical Society of America, and the American Physical Society. He received an honorary Dr.Sci. degree in June 1993 from JATE University in Szeged, Hungary. Since 1996 he has been an Associate Editor of *Applied Physics B*.

CREOL, The College of Optics and Photonics

August 6, 2013

Dr. Ahmed Tewfik
Cockrell Family Regents Chair in Engineering
Chairman, Department of Electrical and Computer Engineering
The University of Texas at Austin
Austin, Texas 78712-0240

Dear Professor Tewfik,

I am writing this letter to express my strong support for Dr. Mikhail Belkin for his tenure evaluation.

I know Dr. Belkin since approximately 2007 through our meetings at conferences and through having numerous discussions. Mikhail is known as a world expert in quantum cascade lasers, specifically quantum cascade lasers operating in the THz frequency range. His papers: "Terahertz quantum cascade lasers with copper metal-metal waveguides operating up to 178 K", Optics Express 16, 3242, (2008); "Widely tunable single-mode quantum cascade laser source for mid-infrared spectroscopy ", Appl. Phys. Lett. 91, 231101 (2007); " Terahertz quantum-cascade-laser source based on intracavity difference-frequency generation", Nature Photonics 1, 288 (2007); "Room temperature terahertz quantum cascade laser source based on intracavity difference-frequency generation", Applied Physics Letters 92, 201101 (2008) - were all cited more than 100 times.

THz quantum cascade lasers still can operate only at cryogenic temperatures. Mikhail Belkin played a major role in surpassing this limitation by creating a room temperature terahertz quantum cascade laser, which utilized intracavity difference-frequency generation to generate THz waves produced from mid-IR waves. His most recent invention is terahertz sources based on Cerenkov (non-collinear) difference-frequency generation in quantum cascade lasers at room temperature, which paves the way toward high power room temperature semiconductor based THz lasers.

During his PhD work at Berkeley, Dr. Belkin pioneered new methods of spectroscopy of liquids on surfaces, based on sum-frequency vibrational spectroscopy. His Phys. Rev. Lett. 85, 4474 (2000) paper has also more than 100 citations.

I attended several invited talks by Dr. Belkin, which he presented at conferences (the last one was THz workshop in Edinburgh, UK in February 2013). These talks were always a pleasure to

University of Central Florida

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attend, because of the clarity, excellent presentation style and new interesting results and ideas that he shared with the broad audience.

Based on his outstanding technical accomplishments and presentation skills, I enthusiastically recommend Dr. Mikhail Belkin for the advancement in rank to the position of Associate Professor at the University of Texas at Austin.

Sincerely,

Dr. Konstantin Vodopyanov
21st Century Scholar Chair & Professor of Optics
CREOL, College of Optics and Photonics,
University of Central Florida, Orlando, FL 32816
vodopyanov@creol.ucf.edu
http://www.creol.ucf.edu/People/Details.aspx?PeopleID=9927

Jilda Gayle

From: Konstantin Vodopyanov <vodopyanov@creol.ucf.edu>
Sent: Tuesday, August 6, 2013 5:07 PM
To: Bearden, Carole A
Cc: Tewfik, Ahmed H; Jilda Bolton (jildagayle@gmail.com)
Subject: Re: Letter of reference for Dr. Mikhail Belkin
Attachments: Belkin_Ref_letter.pdf

Importance: High

Dear Colleagues,

Please find attached a letter of recommendation for Dr Mikhail Belkin.

Sincerely

Dr. Konstantin Vodopyanov
21st Century Scholar Chair & Professor of Optics
CREOL, College of Optics and Photonics
Univ. Central Florida, Orlando, FL 32816
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vodopyanov@creol.ucf.edu

On 201379, at 11:55, Bearden, Carole A wrote:

> Dr. Vodopyanov,
>
> Thank you for your support of Dr. Mikhail Belkin's promotion and agreeing to write a recommendation letter. Attached is a formal request for the letter with a website, logon and password to access his information as well as his CV.
>
> Best regards,
>
> Carole Bearden
> Executive Assistant
> The University of Texas at Austin
> Electrical and Computer Engineering
> ENS Room 236
> 2501 Speedway, C0803

Dr. Konstantin L. Vodopyanov

21st Century Scholar Chair & Professor of Optics
Mid-Infrared Combs

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CREOL A113 (Office)

Biography

Konstantin L. Vodopyanov obtained his MS degree from Moscow Institute of Physics and Technology ("Phys-Tech") and accomplished his PhD and DSc (Habilitation) in the Oscillations Lab. of Lebedev Physical Institute (later General Physics Inst.), led by Nobel Prize winner Alexander Prokhorov. He was an assistant professor at Moscow Phys-Tech (1985-90), Alexander-von-Humboldt Fellow at the University of Bayreuth, Germany (1990-92), and a Royal Society postdoctoral fellow and lecturer at Imperial College, London, UK (1992-98). In 1998, he moved to the United States and became head of the laser group at Inrad, Inc., NJ (1998-2000), and later director of mid-IR systems at Picarro, Inc.,CA (2000-2003). His other industry experience includes co-founding and providing technical guidance for several US and European companies. In 2003 he returned to Academia (Stanford University, 2003-2013) and is now a 21st Century Scholar Chair & Professor of Optics at CREOL, College of Optics & Photonics, Univ. Central Florida. Dr. Vodopyanov is a Fellow of the American Physical Society (APS), Optical Society of America (OSA), SPIE - International Society for Optical Engineering, UK Institute of Physics (IOP), and a Senior Member of IEEE. He has > 325 technical publications and is member of program committees for several major laser conferences including CLEO (most recent, General Chair in 2012) and Photonics West (Conference Chair). His research interests include nonlinear optics, laser spectroscopy, mid-IR and terahertz-wave generation, ultra broadband frequency combs and their biomedical applications.